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ENGINEERING ANALYSIS
OF A
MINING SHARE

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ENGINEERING ANALYSIS
OF A
MINING SHARE

BY

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FIRST EDITION

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PREFACE

In the following pages I have endeavored to set forth considerations which, it seems to me, enter logically into the analysis of a mining venture. The success of any mining undertaking hinges on the correct application of engineering principles. Therefore, to be comprehensive and accurate, the investigation of that undertaking should be approached from an engineering viewpoint. I have applied the analysis to a single share, since the figures resulting therefrom are more easily handled and more readily comprehended. Obviously, the analysis by shares is equivalent to the analysis of the whole property.

Two technical books of the highest order, which were widely read and discussed, and which treated on certain phases of the same subjects, have preceded this publication. They are "Principles of Mining," by H. C. Hoover, and "The Cost of Mining," by J. R. Finlay. I tender my acknowledgments to the authors of these admirable works where there is any overlapping of ideas.

The discussion is on broad lines and is based on observations during twelve years' experience in South America, Mexico, the United States, Canada and Africa.

After reviewing some features which, in my judgment, should be given weight in the investigation and valuation of a mining enterprise, I have endeavored to give concrete application of some preceding generalities. This I have tried to accomplish through an analysis of the affairs of four producing and profitable mining companies. I am, however, not offering a personal appraisal of the worth of the companies reviewed, but have merely developed a line of investigation based on data which are available to the average shareholder. In other words, I have endeavored to eliminate the personal equation, since neither endorsement nor criticism of these companies is implied.

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The discussion confines itself to gold, copper and silver, with limited reference to lead and zinc. No attempt is made to include coal and iron.

Where English equivalents are involved, the pound sterling is taken at $5.00 and the value of one pennyweight of gold at $1.06. Due to the varied sources consulted, some errors may inadvertently have entered into the calculations and text, and corrections or criticisms will be welcomed.

J. C. Pickering.

Whitehall Building, New York,
September, 1916.

ERRATA

Page 57, Table 2: "Number of years of life required to yield 20 per cent" etc. should read:

"Number of years of life required to yield — per cent interest"

Page 82, 19th line from top: " —— gave an average of $55 over 33 in", should read:

" —— gave an average of $55 per ton over 33 in"

PICKERING: ENGINEERING ANALYSIS OF A MINING SHARE

CONTENTS

PAGE

PREFACE v

CHAPTER I

CLASSIFICATION OF MINING PROPERTIES 1

Three broad types discussed: (*a*) properties in process of development, (*b*) producing and profitable mines, (*c*) developed but inoperative or unprofitable properties which may be worked at a profit, with examples under each group and a review of the effects of individual vs. company control, and metallurgical developments.

CHAPTER II

DEVELOPMENT COMPANIES. 17

A discussion of the methods employed and of the results obtained by several representative development companies with remarks on the speculative chances of this type of undertaking.

CHAPTER III

ELEMENTS TO BE CONSIDERED IN THE ANALYSIS OF A MINING REPORT. 23

A review of the effects and relative significance of geographical situation, transportation facilities, climate, labor problems, topography, water and timber, geological features and occurrence of the ore bodies, tonnage and value of ore reserves, metallurgical treatment of ore, costs and profits.

CHAPTER IV

OPERATING PROFITS VS. DIVIDENDS 43

The substantial difference between these two emphasized by examples of groups of properties located in the Transvaal, Rhodesia, the southwestern United States and Alaska with a statement of the items which absorb the difference and a reference to other instances. A discussion of methods employed to temporarily increase dividends namely selective mining, reduced development, employment of unsuitable mining methods and the improper maintenance of equipment.

CHAPTER V

DETERMINATION OF THE VALUE OF A MINE OR MINING SHARE. . . . 53

The worth and application, with examples, of interest, dividend and discount tables for calculating the "present value" of a productive or deferred undertaking and a discussion on the limitations of these tables. A comparison of the rates of interest on which various types of mining ventures are often considered.

CHAPTER VI

PAGE

VALUING MINE PRODUCTS. 61

A review of the statistical position of copper, lead, zinc, tin and silver with remarks on the factors which influence their selling price.

CHAPTER VII

WORLD'S GOLD PRODUCTION WITH A REVIEW OF THE WORLD'S GREATEST GOLD-FIELD 64

The world's production of gold and the relative importance of the Rand of South Africa, with statistics. The significance of declining yields and increased output, the creation and importance of powerful holding companies with their bearing on the financing of properties, the life of the gold-fields and a discussion of local operating conditions.

CHAPTER VIII

MINING VS. INDUSTRIAL AND OTHER TYPES OF INVESTMENTS WITH AN ANALYSIS OF THE AFFAIRS OF TYPICAL MINING COMPANIES . 70

A discussion on the relative safety and worth of mining undertakings. The concrete application of preceding generalities through an analysis of the operating and financial condition of the New Modderfontein Gold Mining Co., Ltd., Brakpan Mines, Ltd., Lonely Reef Gold Mining Co., Ltd., and the Utah Copper Company, with conclusions.

INDEX 93

THE ENGINEERING ANALYSIS OF A MINING SHARE

CHAPTER I

Classification of Mining Properties

INTRODUCTION

The trend of events of the past decade indicate a broadened interest in legitimate mining and in that particular phase of the business which has to do with the close appraisal of mining ventures. Successful development companies, financial groups and others approach mine investment from an engineering viewpoint, and it is the intent of this work to set forth the considerations which influence these types of experienced investors in their selection and valuation of properties. Whether we are dealing with a whole mine, or a fractional portion of that mine—namely a share—the same methods of analysis are applicable.

Mining securities have, broadly speaking, underlying them either, (A) mining properties not yet producing but in various stages of development, where engineering experience leads to the belief that the valuable products can be recovered and marketed at a profit; (B) mines with a more or less extended and remunerative career whose immediate future is assured as profitable, within the limits of mining ventures, and whose more distant future is reasonably promising; and (C) inoperative, unprofitable or slightly profitable mining properties which, by virtue of additional property purchases, increased amount or value of ore reserves, improved mining and treatment methods and facilities, higher standards of organization, varied rates of output, rising prices or improved demand for the products, etc., may be made to yield satisfactory profits.

It is obvious that of these three arbitrary classifications, group (B) offers the greatest security, since it has a record of prosperity; its immediate future—based on the standards which have proven profitable in the past—is assured, and furthermore it may benefit by most, if not all, of the qualifications of group (C).

I am not proposing, however, that this (B) type of security be considered to the exclusion of the other two. The purchaser of securities covering mining properties which come under classifications (A) and (C) should simply realize that these are to a very considerable degree speculative, and his expectation of profit should be great enough to compensate him for the risk incurred. After all, the securities of an unproductive mine represent the capitalization of estimates or expectations. Until the products of that mine have been sold there is no assurance that a promised profit will result. Estimates are not infallible nor do their sponsors necessarily argue that they are.

Examples coming within each of these three broad classifications are given in the following pages:

(A) PROPERTIES NOT YET PRODUCING

We should expect to find under this heading a wide range of ventures. Public offerings may vary from the local syndicate to which a few men are asked to contribute, say $500 each, for the purpose of developing and operating a small but promising deposit, to an immense body of ore with assured reserves running into the millions of tons, with metallurgical problems solved and initial development already accomplished.

In this latter case the public offering of shares will presumably be accompanied by the report of some reputable engineer, wherein we are informed that by development work or drilling there are reasonably assured so many million tons of ore; that during the period of development a test mill has been operated and a suitable treatment process evolved; that an extraction of a stated percentage of the valuable products is indicated; that careful estimates forecast the recovery and delivery at the market of these products at a stated price per unit, and that their market value can be conservatively anticipated to average not less than a stated amount per unit.

The events which have led up to this suppositious public offering may prove worth reviewing. An exploration company or a body of wealthy men have maintained engineers in the field and have been on the lookout for an attractive mining venture for 3 years. The most promising thing encountered is a large mineralized area, located, let us say, in the United States, and a certain amount of superficial prospecting, trenching and sampling has been carried on with moderately encouraging results. It becomes evident that the grade of the material is low and that whatever value the deposit may have lies in its great prospective tonnage and the consequent ability to employ wholesale mining and milling methods. The examining engineer recommends an initial expenditure of say $20,000 in drilling, as being the best means of determining whether or not further expenditure is warranted. Naturally this work is confined to the most likely areas as judged by a general geological examination. The results of this preliminary expenditure are encouraging, and provided material of a more or less similar grade can be disclosed in large quantities, so as to permit of wholesale mining, it is believed that the business will prove profitable. Therefore, an extensive drilling campaign is inaugurated.

We will assume that options running 2 years have been obtained from the owners of the mineralized territory. At the end of a year's drilling, operations are so far advanced as to indicate a considerable assured and a large prospective tonnage. Meanwhile, it is found that the ore is amenable to treatment with slight modifications of standard methods. Laboratory experiments are carried on, and a small experimental mill is erected. This is subsequently enlarged and is run to perfect the details of the process and incidentally check the sampling results.

Toward the end of 2 years, an adequate tonnage of ore has been developed; the chances for further additions are good; the metallurgical difficulties have been solved; sound engineering practice indicates that the ore can be handled at a profit, and the development company finds itself $700,000 out of pocket, being made up of $500.000 spent on the property under investigation and $200,000 outlay during the preceding 3 years of search. They accordingly exercise their options on the property aggregating say $1,000,000 and it is estimated that a further outlay of $5,000,000 will be required to prepare and equip the mine for an output of 5,000 tons of ore per day. A company is thereupon formed to provide adequate working capital, reimburse the development company for its expenditures, which now include the property purchases, and in addition, yield them a handsome profit in cash or shares or both for the extensive initial risks incurred. It is, therefore, this latter company which, we will presume, is offered to the investing public and its affairs are consequently before us for consideration and analysis.

The undertaking just reviewed would therefore come to the public as a relatively clear-cut proposal. The location is excellent; labor, climatic and general conditions are good; the quantity and value of the ore reserves is vouched for by engineers of repute; there are no unsolved metallurgical difficulties; the estimates of costs, based on standard practice under similar conditions, are conservative; the probable average market value of the product is based on fair assumptions and the working capital to be obtained through the issue appears ample. Therefore, we are substantially in agreement with the engineers as to the profits which may reasonably be anticipated on the proposed milling basis. We are, furthermore, informed that within 2 years milling operations will start, and that the payment of dividends is likely to commence about 2 years thereafter.

The property on the proposed milling basis has a life of a stated number of years, and the chances for developing substantial additions to the existing tonnage are decidedly good. Altogether, therefore, granting the ultimate realization of the estimates, we have all the factors necessary for placing a fair valuation on the shares.

In contradistinction to the foregoing rather ideal offering let us consider another, by no means extreme. This time it is a gold-bearing reef in the tropics, one which has been worked on and off for the past 15 years. The history of the mine and of the district is pertinent and has bearing on our present valuation of the enterprise. It is, therefore, worth reviewing.

The proposition was originally floated during a period of boom 15 years ago. It was then partially developed to a depth of 100 ft. The ore was reported to average $20 per ton over a suitable stoping width, and the mine was pronounced a prospective world beater. The public at that time eagerly subscribed for the shares, and the manager—a nephew of the largest stockholder—and his staff were despatched to the property. Money was squandered in building expensive living quarters, erecting a mill which the mine was not prepared to supply with ore, and in the purchase of generally unsuitable machinery. The mill cost double the estimates, and during the period of mill erection the mine was opened in a haphazard fashion. Finally the mill started operation; the recovery was $5 per ton instead of an anticipated $16; the mine was not prepared to supply the mill with the required tonnage of ore; the company became heavily involved; further credit was refused, and the property shut down.

A special meeting of the shareholders was called and an acrimonious discussion ensued. It was finally resolved to raise a limited fund for the purpose of sending an engineer to find out what was wrong. After careful examination and sampling this engineer reports that the available ore assays only $10 per ton instead of $20; that the mill is totally unsuited for the type of ore, yielding a recovery of only 50 per cent. against an estimated 80 per cent.; and that altogether the shareholders' money has been largely thrown away. The property appeared, however, worthy of further development.

An inadequate sum of money was thereupon raised to pay off the debts and carry on development. This work extended over a period of 2 years, with but moderately fair results, and finally operations were suspended for lack of funds. The company thereupon lay dormant for a period of years, was resurrected and reorganized 3 years ago, and is today applying for additional funds.

The public is therefore now asked to subscribe capital for the purpose of continuing development, equipping the mine, and constructing a suitable mill. A highly ornamental prospectus accompanies the offering. The proposition is under the control of a group of financiers who have heretofore distinguished themselves as market rather than mining operators. The technical report which is embodied in the prospectus is by an engineer who is not widely known. We are given a description of the workings, lengths and widths of payable reef, and informed that the ore reserves are estimated at 200,000 tons averaging $8 per ton in gold over a width of 6 ft. A general section of the mine accompanies the report, and by reference to the descriptions we are able to check approximately the tonnage figure. We are informed that it is proposed to erect a cyanide mill with a capacity of 5,000 tons per month and that experiments indicate a recovery of 90 per cent. An elaborate estimate of costs is appended, and we are advised among other things that since native labor costs on the average only 60 cts. per day, against say $3.50 in the United States, some record-breaking achievements are anticipated. On the basis of these cost and extraction estimates there is set forth an attractive statement of expected profits, which if realized will yield 40 per cent. annually on the investment.

However, we have some knowledge of the field in which the mine is located and of local conditions. We know, among other things, that the climate is deadly, all white employees being engaged on a 2-year basis—of which 18 months is spent at the mine and the balance away on full pay. This naturally deters the better class of men from engaging themselves and obviously prevents continuity of management.

The native labor we know to be lazy, inefficient, unreliable and generally hard to obtain, and although the wage is low, they are really—considered from the standpoint of work accomplished—about 50 per cent. more expensive than the $3.50 per-day miner of the United States. The gold field is served by a railroad, but operating charges are high, deterioration of equipment is heavy, and traffic limited, so that oppressive freight rates are charged and the cost of supplies, when laid down at the mine, is almost double that which obtains in well-located mining communities. Mining conditions are complicated by a complex system of faults. The cyanide process has not been uniformly successful in that field due to the occasional presence of graphite, particularly with depth. Finally, due to climatic and other special conditions, wooden structures are practically useless, deterioration is extremely rapid and steel and concrete construction must be almost generally adopted.

Our judgment of the outlook, therefore, is that the condition of the bottom of the mine shows no improvement over the upper levels; that a considerable proportion of the so-called ore reserves will in all probability never be mined due to extensive and complex faulting; that local conditions indicate that the estimated operating costs are about one-half what they should be; that the milling problem may by no means be as simple as we are led to believe; that the equipment of the mine and construction of the mill will probably cost 50 per cent. more that the estimates, and that taking everything into consideration the property will probably prove a losing venture.

The two foregoing examples may appear hypothetical—they are in reality based on two actual occurrences, which however have in each case been somewhat distorted in order to emphasize the point I have had in view.

(B) PRODUCING PROPERTIES

Under this classification I propose reviewing the affairs of three companies.

The first is a copper mine of the porphyry type situated in the southwestern United States. It has been in operation for the past 8 years, and has an assured life, at the present rate of production, in excess of 35 years. It is excellently managed and issues suitable quarterly and annual reports. When operating at capacity its output may be conservatively placed at 150,000,000 lb. of copper per annum produced at a cost of not to exceed 7 cts. per pound, after crediting gold and silver, plus miscellaneous income. It employs steam-shovel mining methods and has so designed its plant and adjusted its organization and operations as to maintain remarkably uniform costs even on the basis of reduced output. It treats an unusually steady grade of ore, which incidentally closely checks the estimated grade of its reserves. The removal of waste capping is well ahead of ore extraction. Its financial condition is excellent—an adequate cash reserve is maintained and it has never reduced its declared regular dividend rate even in times of financial stress. More or less known sums, based on standards of the past, are likely to be applied toward depreciation and prepaid stripping charges. There is not likely to be any marked extension of operations involving great capital expenditure and its existing plants are maintained in a high state of efficiency. Furthermore, metallurgical improvements about to be installed may materially raise the present recoveries and output. Being a copper mine it has naturally, in company with other copper producers, found it necessary to curtail production in order to assist in maintaining the stability of the metal market; but as previously mentioned the thoroughness of its organization and elasticity of its operations is such that this curtailment has had but slight effect upon the cost of production, and furthermore with rising metal prices its financial condition is wisely so strengthened as to assure the continuance of regular dividends through periods of financial and general depression. The principal products of this mine have a variable market value—this feature applying more particularly to copper, since in this instance variations in the price of silver may be considered as negligible.

I know of no type of mining venture which offers greater security than the one just outlined. It is true that special conditions may force curtailment of operations, and that the market value of its principal product is variable. If the product were gold, at least the latter and to a great extent the former consideration would be eliminated, but unfortunately I know of no gold deposit where the operating assurances are as pronounced as in the copper mine just reviewed. In short it would appear that this copper company should not suffer by comparison with any of the usual industrial concerns.

The next example is one of the newer mines of the Rand, located in the Transvaal, South Africa. The product is gold—eliminating, therefore, the consideration of variable metal prices. The mine which has been in operation about 4 years has paid dividends during the past 3 years. It is well-equipped, well-managed and at the inception of operations was believed to represent the last word locally in underground methods and plant design, and today it is typical of the best mining and milling practice of that gold field. There is no intention of increasing the size of the plant and no existing expectation of acquiring additional territory. Operations are well-standardized and there is no immediate likelihood of greatly lowering costs or raising recoveries.

The area owned by this company is toward the eastern end of the Rand—the dip of the reef is relatively flat, averaging about 8°. Up to the present there has been opened about 40 per cent. of the total claim area owned—and the existing developed reserves represent about 4 years' supply of ore at the present rate of crushing. The company's property is surrounded on all four sides by mines in various stages of development and extraction. By virtue of special conditions of ore occurrence which prevail in that field, fortified by the results obtained in the development of the surrounding areas, the market considers that the unexplored 60 per cent. of the company's territory will disclose conditions more or less on a par with those which have obtained in the 40 per cent. opened up. The public, therefore, in its valuation of the security, has given the mine a life of something over 15 years, of which 4 years is represented by the assured ore reserves and the remainder by the unexplored area whose contents are estimated on the above basis.

I shall subsequently review the affairs of two specific Rand companies and in connection therewith discuss in more detail the peculiar conditions which obtain in that field. I merely wish to point out at this juncture an instance where the public, in placing a valuation on the shares, is taking current earnings and applying to them a life factor of 15 years, whereas only 4 years are assured. The experience in that section of the gold field offers some slight justification for the valuation—but needless to say it is extreme.

When properly valued, Rand gold shares are desirable investments. But where market values discount the future in so far as most of the good points are concerned and ignore the eventualities and uncertainties of mining, we are obviously dealing with an undesirable security at that price.

The third property is situated in the western United States. The main geological features are an extremely persistent fissure vein; an unusually high ratio of payable oreshoots to intervening valueless sections, and the lower limits of the ore-bearing horizon pretty well established. The valuable products are principally gold and silver, with minor amounts of lead, zinc and copper. About 75 per cent. of the recovered value is gold. It will be seen, therefore, that varying metal prices affect the outcome to but a limited degree. The management and financial control of the company is in the best of hands and the property is run in the interests of the shareholders. The present company was organized 15 years ago, and has operated continuously throughout that period. With the exception of one year, dividends have been paid since the inception of the concern, but they have varied within rather wide limits. The history of the company is interesting in that it is today operating its third distinct property. The present concern at the time of its incorporation acquired a producing mine. This was not an unqualified success and within a comparatively short time it showed signs of exhaustion, and adjoining areas were taken under option and purchased. Eight years thereafter the second series of purchases gave evidence of repeating the performance of their predecessor, and a further advantageous purchase was made. This third property is probably today at the crest of its career, and a fourth, having recently come under offer, has been bought. All of these purchases have been paid for out of earnings; the issued capital of the company is today substantially the same as 15 years ago, and so far, therefore, it has proven itself a perpetuating enterprise. This condition is entirely due to the foresight, judgment and ability of the financial and technical control. The company in question operates in an isolated camp, and, although it has competitors in its local field, will probably, by virtue of conditions above outlined, be operating after its neighbors have suspended work.

The financial condition of this company is and always has been good. Its balance sheet invariably shows a healthy condition. Extensive cash reserves are uniformally maintained, or if temporarily depleted through the purchase of new territory, are in process of reconstruction. It is this conserving of finances which has enabled the company thus far to perpetuate itself, and, granted unbroken financial control, I consider the chances fair for a reasonable continuance of this policy of perpetuation. The company has today returned to shareholders in the shape of dividends over two and one-half times the original capital and this in spite of the fact that they are operating on the most pronounced type of a wasting asset—namely a relatively narrow fissure vein, with the lower limits of the ore-bearing horizon fairly well established.

The mine shows today ore reserves equivalent to about 4 years' supply at the present rate of production. The unusual persistency of the fissure, and the great length and continuity of the orebodies leads the public to so value the shares that the average of the last 3 years' dividends would have to be paid annually over a period of 10 years to justify the present market price, yield 10 per cent. on the investment, and return the purchase price at the end of that time.

In this instance the holders of these shares are, to a certain extent, capitalizing the known conservatism and the anticipated judgment, foresight and continuity in office of those who now control the enterprise.

By way of review, therefore, I have under the caption "Producing Mines" discussed in a preliminary way three distinct properties, all of them worthy of confidence and, within limits, desirable purchases. The first, a copper deposit being mined wholesale, with an assured long life—the principle variable factor being a changing price for its main product accompanied by occasional necessity for operating curtailment. The second, a large gold mine located in a highly productive region whose assured reserves are limited but the value of whose unexplored areas can in a measure be approximated, and promise a reasonably long life. The third, a mixed-metal mine located in an isolated camp with limited reserves but good chances for lateral continuation of the orebodies—a typical example of a rapidly wasting asset—offset, however, by certain redeeming considerations.

(C) INOPERATIVE, UNPROFITABLE OR SLIGHTLY PROFITABLE MINING PROPERTIES WHICH MAY BE WORKED AT A SUITABLE PROFIT

Within this group come a wide range of mining ventures, which may or may not have suffered, in the past, a multitude of vicissitudes. It frequently occurs that the advent of a railway may usher a mine into the dividend-paying class; that a change in management may turn failure into success; that an altered rate of output—generally an increase but sometimes a decrease—may turn a losing venture into a paying one, and so on through a long list of eventualities.

Mines whose prosperity hinge on an abnormal metal market require no comment, they are usually inoperative the greater part of the time and are merely resurrected during periods of general inflation.

The solution of complex faulting problems has contributed in no small measure to the rejuvenation of apparently exhausted mines. That the solution of these problems is not a matter of chance, but rather of detailed investigation and close study needs no emphasis. A correct interpretation of available faulting evidence has resulted in the discovery of valuable deposits notably in Rhodesia, Mexico and South America, since in these countries, among others, mines were extensively worked by former generations who, apparently, had but little knowledge of the principles and effects of faulting.

The application of suitable underground methods has frequently been the keynote of profitable operations. The development of special methods of stoping yielding a moderate underground extraction at an unbelievably low cost has proven the salvation of some large but decidedly low-grade deposits.

Each property presents its own peculiar problems, and in their correct solution may lie the difference between profit and loss. I recall inquiring as to the advisability of pursuing certain methods employed in the mining and reduction of the great Tanganyika deposits of Central Africa. I was informed that copper ore was the cheapest thing they had; and when the location, environment, high cost of supplies and other peculiar conditions were given adequate weight it was obvious that there was considerable justification for the assertion. In other words, there is an economic limit beyond which operating refinements are not justified.

Individual vs. Company Control.—The introduction of company control is not always an undisguised blessing. It requires a nice balancing of facts, probabilities and possibilities to always turn a mine enjoying individual ownership and prosperity into a profitable company-owned mine. The company has responsibilities which the individual ignores. A mine in Mexico of which I have knowledge is illustrative. The owner competently filled the several positions of board of directors, consulting engineer, general manager, mine and mill superintendent. He was assisted by two foremen, a combination bookkeeper-surveyor-assayer, and the mining and milling crew. There were no frills, his records were simple yet obviously to the point and the property yielded a fair profit. The mine was offered to outside interests and was examined. A moderate tonnage of ore was assured, a fair tonnage indicated, and the bottom looked good. It was believed that larger-scale operations, with some milling refinements, would result in a lowered cost per unit of product, and on this basis the property appeared to be a reasonable purchase, and a company was organized to acquire and operate the mine. Considerable sums were spent in equipment, development, etc., and eventually the mine came into production on the proposed basis. Head office, standing charges, a considerable organization and other items of a nature calculated to relieve the anxieties of the stockholders, more than counterbalanced the gains due to improved recoveries and accelerated production. The net return per unit of product was less than that which obtained under the regime of private ownership. Fortunately developments have been fair, but it is doubtful whether the company will recoup their total outlay plus adequate interest. This state of affairs is largely due to under-rating the ability of the owner and over-rating the benefits of larger operations. Fortunately this is not always the case—it is merely an instance of a possibility.

Metallurgical Developments.—From a metallurgical standpoint there are two developments, now receiving wide application, which are destined to come most prominently before the public eye, since they are in a great measure revolutionary in their effects. They are: (1) flotation and (2) leaching followed by electrolytic or allied methods of precipitation. The extent to which these developments, or modifications of them, may be carried is incapable of prediction. That they will be far-reaching may be accepted as a foregone conclusion.

The leaching of copper ore from a great South American deposit is interesting. The working of this orebody probably antedates the period of the Spanish conquest. Within the past 25 years some of the richest sections of the mineralized area have been exploited in a more or less up-to-date manner, but the vast latent possibilities of the deposit as a whole were not appreciated. About 5 years ago American capital became interested, took many distinct properties under option, started drilling operations, and began an experimental treatment of the ores. These leaching experiments extended over several years, at first in small laboratory lots and subsequently on a larger scale in an attempt to duplicate working conditions. While the metallurgical testing was in progress drilling was energetically carried on, the final outcome being the development of a mammoth body of ore and the erection of an acid leaching plant on a scale hitherto unattempted. The problems which had to be solved were unique and so far as I know without precedent. It was found that the principal ore was a sub-sulphate of copper—a fact not previously appreciated—which under the leaching process supplied an excess of sulphuric acid. This feature has obviously great advantages, if use can be made of it, since the ore thereby supplies enough free sulphuric acid to carry on the leaching process once the initial amounts have been supplied. As against this, however, the engineers had to provide for the elimination of certain soluble impurities in the ore and considerable ingenuity was shown in devising and applying apparatus to overcome this phase of the situation. They also had to adapt established methods of the electrolytic precipitation of copper to their particular conditions.

A copper property situated in British Columbia near the Pacific Coast now gives every promise of being transformed from an indifferent, slightly profitable producer to a substantial and prosperous concern. This change is attributable partly to a vigorous policy of mine development in contrast with the hesitating hand-to-mouth methods of a prior management, but more particularly to the application of the flotation process for the recovery of the sulphides in lieu of previous methods of wet concentration which at the best gave an inadequate yield. The transformation has involved both time and money but the results are gratifying and fully justify the expenditure incurred.

Just what effect some adaptation of the flotation process will have on the future treatment of gold and silver ores remains to be determined; but there is every reason for believing that the application of these two fundamental processes, *i.e.*, flotation and leaching, will be found capable of the greatest elasticity and will be widely distributed.

A review of specific examples of mismanagement, the application of unsuitable processes, faulty plant design, premature or inadequate plant erection and innumerable allied conditions would serve no useful purpose. In some instances mistakes may be rectified and the general position improved. As in almost any other enterprise the success of a worthy mine is largely the outcome of competent technical control. A prominent operator once stated that he wanted no mine which would not stand bad management, but opportunities for securing a mine coming within this category are today—to say the least—few and far between.

CHAPTER II

Development Companies

Before reaching the productive period the best mining undertaking passes through several stages of relatively great speculativeness, and the profit which the purchaser of an interest in the venture is entitled to receive dwindles as the mine reached its era of assured productivity.

The so-called grubstaking of a prospector is probably the climax of a mining hazard. The purchase of shares in an enormous low-grade deposit with a history of regular dividends and a reasonably assured long and productive life, will serve to represent the other extreme. Shares coming within this later classification may be expected, in normal times, to sell on a basis which yields 6 to 8 per cent. plus further sums which if re-invested and compounded return the purchase price at the end of the life period.

If we were to eliminate those ventures which fail to meet the standards of our long-lived investment stock, legitimate mining would shrivel into a dry and unattractive business. The safety which underlies the purchase of a mining security is relative, and as in any other enterprise the yield should vary in direct proportion to the risk.

A speculative type, which is occasionally offered the public, is that of a development company formed for the purpose of looking for and acquiring mines or meritorious mining properties. As an instance we will assume that a company has for its foundation merely the belief that a certain area or country is likely to offer a profitable field for exploration; it owns no mines and has no other productive source of revenue nor special facilities for acquiring information. Its assets, therefore, consist of the subscribed capital, presumably largely intact; a suitable directorate who fully appreciate the risk involved, and a corps of capable engineers. Needless to say, such a venture is highly speculative and the patience of the stockholders is likely to be sorely tried. Under special conditions it may prove a success, but it is sure to prove a tedious uphill fight, and the element of time is a most important factor. Such a concern is likely to spend at least the first 12 months of its existence investigating and eliminating from consideration the great mass of worthless propositions which its competitors have rejected years before. Its success, thereafter, will depend on the value of the field in which it operates and on the capabilities of its engineers combined with the patience of its directorate and shareholders.

As indicative of the great number of properties which are offered a development company and the methods of elimination employed, I quote the following from the annual reports of the exploration department of a prominent American company owning mines and smelters and operating principally in the United States and Mexico. This company has correspondingly broad sources of information together with a large organization from which it can draw.

	Number of properties		
	1915	1914	1913
Presented for consideration	786	639	614
Rejected after office examination	655	538	490
Subjected to preliminary field examination	118	82	100
Accorded complete examination	13	19	24
Properties acquired	3	2[1]	3
Properties taken under option	3[2]	1[1]	3

A large smelting and mining company with diversified and scattered interests can, in my judgment, conduct an exploration department with a greater chance of success than any other conceivable concern. The wide territory

[1] An interest only purchased or optioned.

[2] In one an interest only optioned.

which its operations embrace, the fact that the manager and staff of every mine, smelter and ore-purchasing station which it controls may be considered as scouts constantly on the lookout for meritorious properties, the special information gathered through the purchase of ores, and, furthermore, the fact that at least preliminary and possibly final examination may be carried on at a minimum of expense by the engineers at the unit nearest the property under consideration, all contribute to this advantage. Furthermore, such a company has built up a highly efficient yet diversified organization on which the exploration department may draw, and it can place at the disposal of that department testing and other facilities of great value. In a concern of the magnitude outlined the operating investment and annual turnover, are likely to be enormous, and, therefore, by comparison the exploration branch occupies both financially and otherwise a position of relative obscurity. It is, however, an essential and important adjunct to such an enterprise, and should prove highly profitable.

Four years ago an important exploration company was organized with the primary object of investigating and exploiting Canadian and American mineral resources, the field being subsequently broadened to include other countries. The authorized capital of the company was $5,000,000 divided into 1,000 shares. Of these one-half were issued as fully paid, realizing therefore $2,500,000. The financial plan was unique in that this subscribed capital was to be invested in high-grade bonds and securities, the income therefrom to be applied toward the cost of investigating properties submitted and the general conduct of the company's business. When a suitable property was found it was proposed that the subscribers to this original capital be invited to participate proportionately in the promotion of a subsidiary company. The directorate and principal stockholders of the concern included men prominently identified with extensive mining and industrial undertakings in both the United States and Canada, and it was, therefore, to be anticipated that by virtue of these diversified and indirectly associated interests the chances for successful operation would be somewhat enhanced. A capable corps of engineers rounded out the organization. At the time of its inception the company was appointed consulting engineer to two Canadian mining enterprises of some magnitude which appointment obviously swelled the revenue. The operating charges of the company have run between $80,000 and $100,000 annually which roughly represents 60 to 70 per cent. of the total income. I give these figures purely for the purpose of showing that the proper operation of an extensive exploration company involves a large sum of money. This concern recently closed up its business and the subscribed capital, plus some profits, was returned to the stockholders. Had operations continued they would probably have furnished a useful indication of what a development company, carrying on work purely as such, may be expected to accomplish.

In 1912 an English registered company was organized for the purpose of carrying on exploration and investment work in connection with Russian mining enterprises. Some members of the company's personnel were influential in Russian circles, and the technical control of its affairs was in the best of engineering hands—therefore politically and technically the company was in a favorable position. Through its Petrograd connections the concern secured valuable mineral concessions. The most important of these involved an extensive mineral territory in the Altai region of Southern Siberia and after thorough examination one of the several deposits located within this concession was selected as the most promising from a development point of view. The deposit in question had, under Russian management, been mined rather extensively, operations being eventually suspended due to rebellious ores and water. After careful sampling of the accessible workings, drilling was undertaken with highly satisfactory results. Toward the end of 1914 a substantial tonnage of payable ore had been developed and a subsidiary company was formed and floated to acquire, further develop and work the deposit. In return for the cession of its rights to this deposit, and other considerations, the parent company received 55 per cent. of the authorized share issue of its subsidiary—and after settling various claims today retains 44 per cent. The deposit in question promises to yield substantial profits and the share holding of the parent company will in all probability prove a valuable asset. The concern in question furnishes an example of unusual success, as compared with the general run of development companies. It should be remembered, however, that the company really occupied a highly preferential position. Prior to its formation it had every assurance of securing concessions covering favorably known and mineralized areas—but even granted this, the finding and proving of such a large and valuable orebody within such a limited time constitutes a highly creditable performance. The present position of the company is, therefore, that it holds a substantial interest in a highly promising mine, controls other areas where the indications are very favorable and owns exploration rights over a large region of much promise.

In the foregoing examples I have endeavored to indicate some of the special conditions which can be construed as assisting a development company in its search for properties.

The rigid examination which mines must undergo before purchase will be obvious to anyone who appreciates the inherent risk of mining. The wholesale process of elimination employed in the search for mines has already been noted. A large development company can conceivably spend in excess of a quarter of a million dollars before a suitable property is found which is available on attractive terms. The mine owner almost invariably considers that the average development company is ultra-conservative in its demands and offers—and by the same token he usually holds the most extravagant opinions as to the value of his property.

Any mine, coming within the strict definition of that term, is worth a price, and whether we are dealing with an unequipped but proven deposit, or a dividend-paying property there are a series of standardized features which collectively influence and largely determine the value.

If, therefore, the investor will consider himself in effect an exploration company with the exception that he confine his time and expenditures to the investigation of shares or allied offerings, in which if suitable he proposes to invest; and if furthermore he adopts the same cold-blooded methods of analysis as does his more ambitious contemporary, ignores quotations but looks for values, his investments should prove profitable, subject of course to their being sufficiently diversified and to his business judgment, or that of his advisory engineer, being sound.

CHAPTER III

ELEMENTS TO BE CONSIDERED IN THE ANALYSIS OF A MINING REPORT

A recital of all the elements which might enter into the analysis of a mining report or prospectus would prove too voluminous to be readable, while a discussion of the principal ones may prove interesting.

One or more of the following factors will influence the future of every conceivable mining enterprise. No operating mine stands still—the least that can happen is that it will modify its mining or milling methods to keep abreast of the times. The developed but unequipped deposit is offered the public on a basis of estimates, and into these will enter a great number if not all of the factors I propose reviewing.

In analyzing mining literature the investor need have no fear that the sponsors of the enterprise have, in their presentation, neglected to mention the favorable features of the business—his chief concern can best be directed toward unearthing the adverse items which are rarely printed in bold-faced type. In this respect mining is on a par with any other business.

GEOGRAPHICAL SITUATION

Obviously our first concern is the country. Regardless of assurances to the contrary, the governments of some of the more turbulent Central and South American republics are not on the same footing of stability as those of the United States, Canada or Australia. The recent history of that unhappy country, Mexico, the paralysis of its mines and industries, is too well known to require comment. But revolutionary tendencies on the part of a people are not the sole consideration—the item "taxes" is of some, although relatively minor, importance. Governments, like individuals, must be sustained and their greatest source of revenue is usually derived from their major industry. Furthermore, there always exists the contingency of extraordinary taxes being levied to meet the emergency of war. It is obvious, therefore, that the investor, part of whose interests lie in a country other than that in which he lives, is contributing to the maintenance of two governments.

If, however, the English mining investor were to confine his holdings to companies whose properties lay within the British Isles, his field would indeed be restricted—and it is this necessity for expansion overseas which has so diversified the London Stock Exchange dealings. As opposed to this the average American considers that the great mineral wealth of his own country and its neighbor Canada, offers ample opportunity for profitable investment—although prior to the revolutionary era in Mexico that country also was looked upon with favor.

All other things being equal the mine located within the borders of one's own country is undoubtedly the most desirable purchase. At the same time local opportunities should not blind one to the possibilities of other fields, and in this respect I think the American can profitably inform himself and follow the leadership of his English contemporary. It will broaden the field of opportunity and lead to diversification of interests.

TRANSPORTATION FACILITIES

The proximity of water or rail transportation and the distance to and means of communication with markets will obviously influence the cost of preparation, plant installation and subsequent operation. At a milling property, deriving its power from local sources, the item of "supplies" will represent from 25 to 40 per cent. of the total cost of operation—hence excessive haulage rates which attend all crude methods of transportation are reflected in increased cost of supplies accompanied by a proportionate rise in the expense of operation.

Unfortunately the effects of inaccessibility and isolation do not end here. The mine is required to market its product and if this be wholly or partly bulky, the transportation factor again enters the cost sheets in a prominent manner. All of this, however, reduces to a question of dollars and cents which may within limits be estimated in advance. All of the disadvantages which, from an operating point of view, attend isolation and primitive means of communication are not capable of close appraisal, but on balance they will play a prominent part in the financial history of the property. The uncertainty which attends the arrival of supplies, the time factor due to slow methods of transport, periodical interruptions of transportation due to climatic or other conditions, all have an adverse effect on continuous and efficient operation.

CLIMATE

The maximum of effort will be obtained in neither the tropics of Africa, the heights of the Peruvian Andes or the far north. Abnormal and unsatisfactory climatic conditions affect operations to a pronounced degree.

Take, for instance, the West African *versus* the South African gold fields. The ore occurrence in both cases is decidedly similar, *i.e.*, gold-bearing banket—but the first-mentioned field is in the low-lying, fever-stricken districts of Central Africa, whereas the Rand is at an elevation of 6,000 ft., and the climate is excellent. It is absurd to believe that West African operating costs can ever hope to approach those of the Rand—one of the contributing factors being climate. The central African climate is enervating and unhealthy. Foreigners are usually contracted for on the basis of 9 months on the field and 3 away on leave. This contributes to non-continuity of management, which, combined with poor efficiency due to the enervating climate, plus fever and tropical disorders, is strongly reflected in the operating statements.

Let us consider another extreme—the elevated mountain ranges of Peru where mines of importance are over 14,000 ft. above sea level. Climatic conditions are inhospitable and far from good. The Andes at that elevation are barren of timber and vegetation; it either rains or snows the greater part of the time; and the altitude also lends its aid toward inefficiency. It is irrational to assume that these conditions permit of sustained and effectual efforts on the part of foreigners—consequently they must manifestly have an adverse effect on operating costs.

The importance of climate and environment, and its effect on the operation of any property cannot be too strongly emphasized. For obvious reasons, climate and labor are closely correlated. Labor usually represents 55 to 70 per cent. of the total cost of mining and allied operations, and since adverse climatic conditions are most certainly not conducive to efficiency, the relative significance of climate is evident.

LABOR PROBLEMS

It is often contended, in estimating the future of a mining enterprise, that, by virtue of the extremely low local wage, correspondingly low operating costs will be obtained. In nine cases out of ten this is a fallacy of the most pronounced. type. The native, whose earning power is one-tenth to one-fifth that of the skilled American miner, is usually dear at the price. His is an inferior order of mentality; he is unaccustomed to think for himself, and requires close and constant supervision.

This contention is forcibly brought out by some comparisons made by H. C. Hoover and included in his book, "Principles of Mining." Four groups of gold mines were taken from western America, West Australia, South Africa, and India. I quote the following from his work:

> All of those chosen are of the same stoping width, 4 to 5 ft. All are working in depth and with every labor-saving device available. All dip at about the same angle and are, therefore, in much the same position as

to handling rock. The other conditions are against the white-manned mines and in favor of the colored. That is, the Indian mines have water-generated electric power and South Africa has cheaper fuel than either the American or Australian examples. In both the white-manned groups the stopes are supported, while in the others no support is required.

Group of mines	Tons of material excavated over period compiled[1]	Average number of men employed		Tons per man per annum	Cost per ton of material broken
		Colored	White		
5 American mines[2].....	1,089,500		1,524	713.3	$1.92
6 Australian mines[3].....	1,027,718		1,534	669.9	$2.47
3 Witwatersrand mines[4].	2,962,640	13,560	1,595	195.5	$2.68
4 Kolar (Indian) mines[5].	963,950	13,611	302	69.3	$3.85

On the strength of the foregoing demonstration it seems fairly obvious that we are justified in placing a premium on the intelligence and initiative which is inherent in the higher-priced laborer and which is his greatest contribution toward his ability to command a higher price.

The natural query, therefore, follows that if these improved and very satisfactory performances are obtained through the medium of high-priced labor, why not generally substitute the latter for the inefficient native. Unfortunately there are a number of controlling factors, varying with local conditions, which, when taken collectively, may more than offset the apparent advantages of such a procedure. Three of the most important of these are climate, environment and local customs or conditions. Furthermore, while the average white miner is migratory in his habits it is not reasonable to assume that in normal times he will relish the idea of being transplanted to a foreign soil for the same wage he can obtain in districts

[1] Includes rock broken in development.

[2] Wages about $3.50 per day. Tunnel entry in two mines.

[3] White men's wages average about $3 per day.

[4] About 40 per cent. of the colored workers were negroes and 60 per cent. Chinamen. Negroes average about 60 cts. and Chinamen about 45 cts. per day including keep.

[5] Indian wages average about 20 cts. per day.

with which he is familiar. If he knows that climatic conditions are bad he most certainly will not go, and in any event, unless he expects to materially better his position, he can hardly be asked to accept the unknown for the known. As for local customs, the traditions of generations cannot be broken down over night. Efforts to force this issue have never, to my knowledge, been a success. If the white miner is expected to replace natives in a country where, for generations, all manual labor has been performed by the latter, he will soon prove a discontented and refractory workman.

The logical solution, therefore, is to employ white men in positions of total or partial superintendence, whose direction presumably stimulates the native to such efforts as will result in a fair degree of efficiency.

In South Africa the importation of white labor on a wholesale scale was at one time seriously considered in an effort to solve the problems which confronted operators on the Rand after the repatriation of the Chinese. The proposal was fortunately not carried into effect. A middle course was, however, adopted, so that today black and colored labor working under the close supervision of the white represents, as a whole, a fairly efficient machine. The steady decline in Rand costs is partly attributable to the improvement, due to training and organization, which the South African native has undergone in the past 10 years.

About 8 years ago, in South America, an effort was made to import large numbers of American miners for the purpose of replacing natives in underground work. Out of the first consignment of about 50, but 10 remained at the end of 2 weeks. The climate was wretched, living conditions bad and the customs were foreign and generally unsatisfactory. This attempt to break down local barriers having proven a failure, the more sensible scheme of using the native where possible and employing the white where essential was substituted. The result is that today a moderately intelligent crew of natives has been evolved from apparently hopeless raw material and the general operation, considering local conditions, is good.

TOPOGRAPHY, WATER AND TIMBER

The first of these is incidental to operations, the last two are essential. Topography will influence the method of attack in opening up or mining a deposit; for instance, if adits as against shafts are feasible it may contribute toward a lower cost of operation. It will affect the location and design of the mill or reduction works as well as the means of communication between them and the mine, and affect the scheme for the storage or disposal of tailing or other rejected material. Topography, in conjunction with climatic conditions, will, furthermore, control operations in so far as continuity is concerned. It has a direct bearing on the general scheme of transportation.

An ample and dependable supply of water is a primary consideration, one which is unfortunately often over-estimated. It costs a great deal of money to shut down a mine due to shortage of water and keep it inactive, yet ready to resume operation on short notice. There are standing charges, such as salaries, some wages, generally pumping expenses and other items which must be paid whether the property is operated or not; furthermore, the investment is there whether earning or not. If a prolonged shutdown is inevitable the greater part of the operating force is usually dismissed; this destroys the morale of the workers and generally results in the loss of many of them. A mine, which periodically has to shut down for lack of water, is clearly over-equipped, provided of course that an ample supply is not available. Water is an essential to power generation, milling, and reduction operations, and may be required in connection with tailing disposal. I have seen cyaniding mills in New Mexico and Rhodesia shut down for lack of water, where a storage remedy was feasible, indicating clearly, therefore, a lack of foresight on the part of the management. Prior to the actual shutdown all sorts of makeshifts were employed to eke out a steadily diminishing supply—always at the expense of operations, entailing fouled solutions, a cluttering up of tailing and other features of a similar nature.

Timbered surroundings are generally desirable but not essential. They may be closely related to the water supply and where snow or land slides are prevalent may insure the safety of the camp. They may contribute toward its destruction through fire. Timber, whether for fuel, mining or other purposes, comes under the classification of supplies, and is consequently procurable, if necessary, from distant localities. It is an operating necessity, but unlike water may be brought great distances. There are but few properties where steel has universally replaced timber, and on the Gold Coast of West Africa, owing to the rapid deterioration and destruction of wood, steel should be more generally substituted.

GEOLOGICAL FEATURES AND OCCURRENCE OF THE OREBODIES

Next to the value of the ore the geological features constitute the controlling factors of most mining undertakings. The array of contingencies that may have to be met in the development and mining of an orebody usually far outweigh the metallurgical and other problems —it being assumed, of course, that the ore is amenable to treatment.

All other things being equal, the method of occurrence of an orebody may constitute the dividing line between profit and loss. During the past 20 years some unusually clever caving and other mining methods have been developed and applied to large deposits whereby good percentages of an orebody may be recovered at a cost which in the late eighties would have been considered impossible. Steam-shovel mining, where applicable, is the cheapest known method of removing large quantities of material in a form which permits of its future milling treatment. It is, therefore, these features which have contributed largely toward the profitable working of large low-grade copper and gold deposits in the United States, South America and elsewhere.

In contradistinction to these rather ideal features, it requires no particular stretch of the imagination, to conceive of an apparently valuable orebody whose method of occurrence or whose association with other underground conditions is such as to render it unpayable. The adverse effect which extensive faulting may have on operations is well known—yet faulting may, under special conditions, contribute largely toward increasing the valuable contents of an orebody, as, for example, some of the mines at El Oro, Mexico. Intrusions or inclusions of waste—sometimes called horses—may play an important rôle in the cost of mining. Short and isolated shoots of ore, kidneys, pipes and other occurrences of irregular outline, when of small dimensions and separated by considerable stretches of valueless material, may seriously limit the profit-making possibilities of a mine. The general dip of the orebody—assuming such a term applicable to the occurrence—the character and quality of the enclosing rocks, the presence of heavy, swelling or insecure ground, large amounts of water, excessive heat, and a long list of additional eventualities may have a most important bearing on working costs.

I recall a mine in Africa which combined a relatively flat dip with extensive folding and faulting, complicated by an occasional splitting or duplication of the orebody. The appearance of the workings, tortuous in the extreme, may well be imagined. The stopes due to the folding of the deposit lay at all angles, and by virtue of frequent faulting they were of necessity short. Fortunately the grade of ore was such as to permit of profitable mining even under these highly adverse underground conditions.

An extensive African gold deposit, which I had occasion to examine, was represented as being an exceptionally good mining property except that one or both walls, it being a vein, frequently carried for extended distances rather large amounts of graphite. At such points the ground was inclined to be heavy with the result that, in mining, there was a continued slacking off and dilution of the ore with this highly objectionable graphitic rock. The results, while unfortunate from a mining point of view, had their chief effect in the treatment problem, eventually necessitating the installation of a complicated plant with attendantly increased metallurgical costs, so that today the mine is failing to yield the anticipated profits.

I might cite a number of additional examples, which, however, would serve no useful purpose. I merely wish to point out some of the underground conditions which may vitally effect the value of a property.

TONNAGE AND VALUE OF ORE RESERVES

These are obviously of underlying importance in any mining business—they form the basis of an appraisal of probable earnings. They are capable of determination within variable limits. They must, at the best, involve estimates and the personal equation plays an important rôle.

Ore reserves are valued on the basis of sampling accessible exposures of ore, or by churn, diamond or other drilling methods. The assay returns, widths and other data are thereafter plotted on an assay plan, from which in turn the tonnage and value of the reserves may be calculated. The assay-plan results are capable of the widest interpretation in the calculation of ore reserves, and it is in the final estimates of tonnage and value that the personal equation may be most in evidence and that judgment and experience is of the most value. I do not, however, wish to be considered as attempting to minimize the importance of sampling, for in experienced hands there are very few exposures of ore which are incapable of fairly accurate determination.

In the interpretation of the sampling results, there arises the importance to be attached to high values whether they be more or less isolated or in moderately regular sequence. Moreover, in some types of deposits—particularly in narrow ones—the probable stoping width is important. For instance, one can easily conceive of an oreshoot assaying $12 per ton in gold and silver over an average width of 3 ft. and located within a well-defined fissure whose average width is 4 ft., the difference being made up of practically valueless clay selvage occurring on one or both walls. It is quite likely that, in the case under review, the entire width of 4 ft. would have to be broken in stoping and the resultant material would therefore assay but $9 per ton. If it were found impracticable to separate the selvage from the ore by hand sorting, or some similar preliminary means, it is obvious that material of but $9 grade would be delivered to the reduction works.

The hypothetical instance just cited is simple in the extreme, but using this as a base the outlook for complications will be apparent. The two items—the treatment of high assays, and the likely stoping widths—may be considered the crux of the situation, assuming of course that the sampling and assaying results have been adequately checked and found reliable within economic limits. Deposits are occasionally encountered on which no sane engineer would undertake to offer estimates as to ore reserves; others are so regular, in so far as values, widths and stoping conditions are concerned, as to offer no logical ground for disagreement in the way of estimation. As between these two come a graduated range of occurrences, some of which may entail serious disagreement in the estimates of engineers who have conducted independent examinations.

On broad lines it may be stated that from the average mine the ore as stoped will, on balance, assay 10 to 15 per cent. less than the sampling returns, and that the volume will be correspondingly increased. The principal reason for the discrepancy appears to lie in the inability, under operating conditions, of stoping ore within the fine limitations indicated by the assay plan, assisted by unexpected inclusions of valueless material. The main contention favoring such a statement is founded on experience. The figures mentioned represent, in my judgment, a factor of safety, fortified by experience, of which the engineer should make more common use.

The development of churn drilling in connection with the proving and estimation of several prominent low-grade copper deposits has thrown interesting light on this phase of the situation. In an orebody carrying in excess of say fifty million tons developed by drill holes spaced at 200-ft. intervals, it is difficult for the investor, who has no access to the assay plans, to state at the end of 5 years' operation, that the grade of the ore as mined is falling within or below the original estimates unless, of course, the discrepancy be glaring. Even with access to the plans the issue may, in steam-shovel mining, be clouded by the admixture of waste due to imperfect capping removal, or by involuntary but sometimes essential dilution by capping as in the case of some caving methods. That valuable teacher, experience, has, however, shown that churn-drill sample averages—even employing due precautions in the elimination of abnormal assays—are inclined to be high, so that in two copper ventures, which in 1915 were widely discussed, substantial arbitrary reductions were made. In the first case 300,000,000 tons were at stake—with an average grade of 2.13 per cent. copper—which was arbitrarily placed at 2 per cent. In the second, involving over 110,000,000 tons, the grade was placed at 2.5 per cent. whereas the drill-hole averages called for 2.84 per cent.

In the statement of ore reserves as conveyed to the public, the engineer will usually group his estimates into such classifications as meet the case in hand. Numerous arbitrary divisions have been put forward by as many sponsors—a more or less general one being:

Ore in sight—*i.e.*, developed on four sides, and which can be looked upon as continuous with a considerable degree of assurance.

Probable ore—*i.e.*, developed on three sides with fair indications of probably proving continuous.

Possible ore—i.e., developed on two sides or less; this constitutes in reality ore expectant, but unknown both as to quantity and value.

Many engineers report ore reserves without qualifying classifications. They sometimes consider that by virtue of their experience, and special knowledge of the deposit under consideration, such a form of estimate is desirable, and in such cases they frequently include in the tonnage estimates ore beyond the exposures. Under certain conditions this practice may be followed with some degree of security; under others it would be open to much criticism.

METALLURGICAL TREATMENT OF ORE

The premature erection of metallurgical plants, or their design on the strength of inadequate or faulty-treatment experiments has done incalculable injury to legitimate mining. The landscape of the western United States, and, in fact, of most mining regions of the world, is dotted with mills and other metallurgical units for which there was no ore, or which failed to treat economically such ore as was available.

A few years ago I had occasion to advise some clients with respect to a so-called large gold mine in the western United States. The owners had invested considerable sums in the venture, and were the possessors, among other things, of plans showing a mine with extensive workings and photographs of an apparently large mill. The mine under previous ownership had yielded a considerable amount of ore which had been sold to custom mills in the vicinity at an adequate profit. With the exhaustion of the bonanza bodies the prior owner consented, after prolonged negotiations, to part with his interest for what struck me as a handsome consideration. One of the first things to be done, therefore, was to construct a mill which could do justice to the "large reserves of medium-grade ore." Ignoring local experience, a large mill was designed and erected with the anticipation of eventually running the surviving custom plants out of business. To do it justice, it really did run for something over a month, but it soon developed that it was failing to treat the ore on a par—from the point of view of recoveries and costs—with the local mills. Furthermore, the "large reserves of medium-grade ore" were large reserves of waste in so far as profits were concerned. The owners having arrived at that conclusion, much to the annoyance of their manager, I had the pleasure of looking into the business. In the course of the examination it became apparent that the mine could not hope to supply the mill with payable ore during even 2 days a week, that the value of the ore and factors affecting the economic recoveries had been badly over-estimated, and that altogether it might yield a small profit if turned over to leasers who would in turn sell their ore as before to the much-despised custom plants.

The facilities which exist in most mining centers for carrying on tests in upward of ton lots are so good, and there are so many reputable metallurgical engineers available who have a record of success, that it seems incredible that an absolutely unsuitable mill should be erected.

It should not be inferred that, by adopting these precautions, the risk of failure is eliminated. Engineers in common with general humanity are liable to errors in judgment. But it can be said without fear of serious contradiction that by proceeding cautiously in the development or application of a process, fortified by competent metallurgical talent, the risk of serious failure is minimized.

The practice of over or premature equipment cannot be too strongly condemned. In the mad rush to make a showing inadequately developed deposits are frequently saddled with a mill to the demands of which the mine cannot respond. The uncertainties of development are proverbial. It is folly to anticipate nature by installing a treatment plant unless the cost of the same can be returned ~~at least twice~~ on the basis of sound conservative estimates.

A general application of the principle that an accelerated output will result in a lower cost per unit of product is a fallacy. Certain types of deposits can, it is true, be made to pay only by wholesale operations. Other types have yielded more per unit of product under private ownerships and with limited output, than subsequently when controlled by an ambitious company and operated on a greatly enlarged scale. There is an economic limit to output, and while it can be shown mathematically that the maximum return is obtained through the rapid exhaustion of a deposit, nevertheless it is but rarely that this principal can be applied.

The care, foresight and attention to details which should characterize the development and application of a suitable process and the design and erection of a treatment plant are amply repaid in successful operation. Hasty or ill-advised action and inadequate financing are usually reflected in the final test of any property, the balance sheet.

The unprecedented operating achievements of the Inspiration Consolidated Copper Co. furnish a conspicuous example of what may result from the careful development of a mine, a treatment process, and the thorough preparation and equipment of a property. Needless to say the present operations at that mine are due to the ability, wisdom and foresight of the directors and engineers of the undertaking.

COSTS AND PROFITS

Into these two items will enter estimates as to the amount and average value of ore in the mine, the cost of turning this into money, and the capital expenditure and time necessary from first to last to bring the property to the proposed stage of productivity and maintain this rate. It will be obvious, therefore, that the underlying elements which enter into these estimates are: (*a*) the cost of labor, (*b*) the price of materials, and (*c*) the time.

Enlarging somewhat on these basic essentials we may state that an estimate of costs will have due regard to the quantity and character of the work under consideration, the physical conditions under which it will be carried on, the price and quality of materials and labor together with their tendency to fluctuate during the period of operation, the technical skill employed in laying out and carrying on the work, and the assumption that the undertaking will be concluded on the proposed basis without serious modification, together with due allowance for the unforseen, *i.e.*, contingencies, affecting as they will both cost and time.

Whether we are dealing with a mine of recognized standing in the dividend-paying class, or a prospective venture in some remote region, estimates will, sooner or later, play an important rôle in the present and future valuation of the property. Therefore, the investor at some stage finds himself confronted with a query as to the amount of reliance he can afford to attach to the estimates. In reality he places himself largely in the hands of those who constitute the technical control of the property, and he should only do so after satisfying himself as to their integrity and ability to carry the work to a successful conclusion. The technical control is usually appointed by the directorate; with these latter the shareholders may or may not come into actual contact. The directorate plus the engineers constitute the responsible members of the organization and on their joint efforts may hinge to a considerable degree the success of an enterprise.

Engineers who have been closely connected with the growth of a promising or successful mine usually develop a more or less justifiable optimism. It has been my experience that we are all inclined to under-rate that most important element, time. Most properties, which have had successful engineers for their sponsors, have ultimately come up to the expectations and predictions of these men. It is most unusual, however, to find a property which has done so within the time limit set or at the anticipated cost in so far as capital outlay is concerned. It is unfortunate that such is the case, but granted ultimate realization of the vital estimates, I do not think that initial setbacks should be open to unreserved condemnation.

For instance, take the case of an engineer who has undertaken the equipment and bringing to production of a hundred-million-ton deposit, averaging a recoverable value of 30 lb. of copper per ton. He estimates that within 2 years the mine will be completely prepared and equipped, with a 10,000-ton per day plant erected and the entire cost will be $10,000,000. He furthermore states that within 1 year thereafter the mine will be working to capacity and turning out copper at a cost of 8 cts. per pound and that a 7-ct. cost will be reached and maintained during the following year. Let us assume that due to the usual contingencies of mining it takes 3 years to get things going on a 10,000-ton per day basis and that the out-of-pocket expenses at the end of this period are $15,000,000. Furthermore, at the end of the fourth year the costs are 9 cts. per pound of copper, 8 cts. at the end of the fifth, and 7 cts. at the end of the sixth year and thereafter. Let us assume that the operations substantiate the estimates as to tonnage and recoverable grade of the reserves. If we place the selling price of copper at 14 cts. per pound the mine will, on the basis of the 7-ct cost, yield an ultimate operating profit of about $200,000,000. It seems to me that in an instance such as that outlined one should consider the error from a relative point of view. The ultimate realization of the pertinent estimates far outweighs in point of importance the early discrepancies. These latter are decidedly disquieting from an immediate point of view, and encourage doubts during the period of uncertainty and transition. From an ultimate viewpoint, however, their significance dwindles.

One of the most serious conditions with which the engineer has to contend is inadequate financing. Most properties at some stage of their career call upon the public for funds. The United Verdes are few and far between. If we are dealing with a proposal for equipping a partially proven mine with the expectation of realizing some estimated profits, we may rest assured that if the public offering is to be a success, the anticipated income return, say 3 years hence, must be handsome, obviously entailing when realized a considerable appreciation in the price of the shares. In other words, a deferred venture such as I describe must promise a highly satisfactory yield in view of the risk incurred. This yield is calculated on the investment; naturally, therefore, the banker, who lacks enthusiasm for undigested offerings, is interested in keeping the initial investment at a reasonable minimum. He may or may not realize that the funds he proposes to provide fail to cover the great array of contingencies. He has, however, satisfied himself as to the intrinsic worth of the undertaking; he does not overlook fortuitous happenings but at the same time he sees no necessity for capitalizing them. Moreover, if the provided funds are inadequate, the company's notes can probably within limits be placed privately during the period of equipment, making a later financing coincident with a more or less general realization of the operating estimates. Frequently the plan or scope of the undertaking is altered during the construction period with obvious results. All of these may in one way or another swell the capital outlay by 20 to 50 per cent. of the original estimates.

Frequently the engineer in planning extensive additions to a mill or smelter is called upon to modify and make use of obsolete or unsuitable equipment in an endeavor to meet specified financial and operating conditions. I can imagine nothing more unsatisfactory, and from my experience it involves a short-sighted policy of the most pronounced type. Under special conditions, such as a mine approaching exhaustion, it may be desirable, but I know of nothing more diametrically opposed to efficiency than a makeshift plant.

In the fall of 1915 I was discussing this point with a highly successful contractor. At that time he had several operations underway involving between two and three million dollars each. He stated that his equipment on a typical contract might cost $300,000, and that with the work completed it might be worth $50,000 to $100,000. One particular contract had terminated, and his bid had been accepted for a similar piece of work entailing a like amount of money and similar equipment. In preparing his estimates for the new work he had figured on an entirely new outfit, had no intention of employing any appreciable part of what was usable of his old paraphernalia and attributed some of his success to the fact that his plant and tools were never makeshifts, but rather the most up-to-date and suitable available and that the gain in efficiency more than counterbalanced any short-sighted loss entailed in scrapping or selling for next to nothing the previous outfit.

The earning power of a developed but unequipped property entails the maximum number of estimates, the producing mine the minimum. Into the former will enter estimates as to: (*a*) the tonnage and value of the reserves, and comments on the likelihood of continuity; (*b*) the capital expenditure and time necessary to bring the mine to the proposed stage of productivity; (*c*) the ultimate cost per unit of product, which involves among other things both the operating costs and the metallurgical recoveries; and (*d*) the probable average market value of that product.

We have already seen that there are grounds for anticipating a variation between the value of the ore as calculated from sampling and its milling value, and that the latter might reasonably be expected to average but 85 to 90 per cent. of the former. There furthermore appears to be a tendency to under-estimate the expenditure and time necessary to bring the property to the proposed state of productivity.

It has seemed to me that undue impatience is often shown in judging the operations of a new property. The investor often fails to appreciate the magnitude of some present-day plants. A 10,000-ton per day mine about to start might well occupy at least a year and probably two, in perfecting its organization, synchronizing the operations of its various departments, or in short tuning up to the proposed rate of output. This necessary lapse of time is naturally not conducive to a spirit of optimism, in so far as the investor is concerned, but at the same time I believe experience should have shown him the wisdom of anticipating such an occurrence.

I think, therefore, that the investor who holds an interest in a property about to be equipped, with the intention of retaining that interest, through at least a portion of the operating life of the mine, should bear in mind three probabilities: (1) It will probably cost more to bring the property to the productive stage than was anticipated. This may partially be due to a change in the scope of operations during the period of equipment, since it is sometimes found desirable to prepare certain departments of the undertaking for larger output. (2) The realizing of the estimated operating cost per unit of product will probably take longer than anticipated. (3) The realized operating profit, *i.e.*, the difference between the operating cost and the yield, is not likely at any time to reach the shareholder in the shape of dividends. He may get 80 per cent. of it, possibly less and seldom more.

The factor of safety which one is justified in applying to each of these three probabilities varies, naturally, with individual cases. To judge these likelihoods fairly, one must have available the essential data bearing on the undertaking under consideration.

CHAPTER IV

OPERATING PROFITS *versus* DIVIDENDS

Ignoring interest, the net return from a mine is the difference between the marketed value of its product and the cost of the property, its development, preparation and equipment, plus the total expense incurred in turning the ore into money. The operating cost is rarely the total expense. There is usually a substantial difference between the so-called operating profit of a mine and the amounts actually transferred into the shareholders' pockets in the shape of dividends.

Mining companies usually report annually, among other things, the yield and the operating cost. He who expects that the difference between these two usually referred to as the operating profit, will be disbursed as dividends is likely to experience some serious disappointments. Operating profits and earnings are generally, but not always, synonymous. On the average decently managed mine the shareholder will be wise to reckon that, over the life of the property, not more than 70 to 80 per cent. of the declared operating profits will be paid as dividends. As an accounting curiosity the difference can easily be located along with the post-mortem examination of the mine. It can also be located from time to time when necessary during the productive life of the mine with the exception that in the former case we are faced with cold facts, whereas in the latter we may conjure ourselves into believing that while, over the period reviewed, the statement is true, nevertheless the mine was then passing through an extraordinary stage of its career and that hereafter unusual expenditures will be unnecessary and a high percentage if not all of the earnings will be paid as dividends.

The average investor will at some time or other comfort himself with this argument, and his contentions may be justified until another one of those so-called extraordinary situations arises—with the passing of which he may again revert to his pleasant anticipations. The history of mining teaches us, however, the fallacy of such assumptions. Mining entails a succession of fortuitous happenings and the inroads which these will make on dividends should be recognized. It is not to these, however, that the difference is entirely chargeable—there are a large number of items which regularly enter into the balance sheet which are not considered as operating charges but which have to be met out of earnings. The relative amount of these charges varies with the accounting methods employed.

The following tabulation sets forth statistics of the Rand gold field of South Africa as reported by the Transvaal Chamber of Mines:

	1915	1914	1913
Tons milled	28,315,000	25,702,000	25,628,000
Yield	$186,325,000	$170,622,000	$179,063,000
Operating profit	$59,655,000	$57,768,000	$60,946,000
Dividends declared	$38,097,000	$40,367,000	$40,970,000
Per cent. of operating profit paid as dividends	63.9	69.9	67.2

This is a record of the field as a whole. It combines the barely payable with the highly profitable companies. On some of the former, less than 50 per cent. of the operating profit may be paid as dividends; on some of the latter 80 per cent. or slightly better. The difference goes into profit's tax, workmen's compensation, depreciation, head office expenses, bond or debenture interest and redemption, expenditures for new plant, capital charges, etc.

The following summarizes the operations of four of the largest and most profitable gold mines in Rhodesia over two consecutive and recent years:

	A	*B*
Tons milled	332,000	354,000
Yield	$5,394,000	$5,627,000
Operating profit	$3,537,000	$3,464,000
Dividends paid	$2,315,000	$2,519,000
Per cent. of operating profit paid as dividends	65.4	72.7

One of the properties included above has been and is one of the richest gold mines of the world in so far as the value of the ore treated is concerned; another is a relatively new and moderately rich property which started operations about 1910, and the other two are nearing exhaustion, although they both still have several years of productive life. The combination, therefore, is a representative one. The difference between the operating profit and the dividends paid was absorbed by most of the items referred to under the Rand group.

In American companies the percentage of working profit paid as dividends is often somewhat higher than with English-owned mines. Special circumstances may, however, temporarily at least indicate the reverse. Witness the following combined results of three large porphyry copper mines in the United States. Two of these employ steam-shovel excavating methods, the third underground mining. The position is complicated somewhat by the fact that one of these companies derives a large income from its interest in another copper mining concern, but this should not vitiate the final result.

	1915	1914	1913
Pounds of copper produced	273,624,000	226,694,000	216,796,000
Net operating profit	$26,086,000	$11,383,000	$11,991,000
Net operating profit plus income.	$29,588,000	$14,640,000	$14,776,000
Dividends paid	$11,386,000	$8,086,000	$8,298,000
Per cent. of net operating profit plus income paid as dividends	38.4	55.2	56.1

A substantial part of the difference above noted was absorbed in prepaid charges—stripping in the case of the steamshovel properties, and underground expansion in the case of the other. The balance was absorbed in depreciation, bond interest and retirement, capital charges such as additional equipment, a general strengthening of the financial position and other items. It should also be noted that a large copper mine requires a considerable cash surplus to properly conduct its operations. All three of these mines are well-managed, highly profitable concerns, and it is to be presumed that shareholders will at some future date receive direct benefits principally from such charges as prepaid stripping and development or in other words this work will soon be sufficiently advanced to permit of its subsequent cost being absorbed in the operating figures. Furthermore, with the retirement of all bonds that charge ceases. Such items as depreciation, capital expenditure and others may, however, be expected to continue throughout the life of the mine, and under easily conceivable conditions these may be very large.

Two well-known and profitable gold mines on Douglas Island, Alaska, offer further evidence as follows:

	1915	1914	1913
Tons milled	1,434,000	1,369,000	1,334,000
Yield	$2,871,000	$3,333,000	$3,402,000
Operating profit	$1,063,000	$1,644,000	$1,681,000
Dividends paid	$902,000	$1,262,000	$1,414,000
Per cent. of operating profit paid as dividends	84.8	76.7	84.1

The foregoing examples clearly indicate that on the average mine there are items other than operating charges with which the investor must reckon. Some of these can from year to year be forecasted with considerable precision by referring to past records of the property. Others which cannot be foretold may at times reach substantial figures and it is to these that I wish to direct attention. What should be the most obvious of these comes under that elastic item—*depreciation.* A depreciation fund should imply a cash reserve established for the purpose of maintaining the buildings, plant, equipment and other essentials to effective operation at a high state of efficiency or in other words counteract the loss in value which would normally occur. Depreciation is properly an operating charge although it is rarely handled as such. The design, and construction of equipment is constantly being improved; the advances made in the art of metallurgy need no comment, and a mine which can, from the viewpoint of economics, profit by these improvements or advances must do so. The cost of installations or replacements to keep abreast of the times is properly an operating charge. Such an expense is inevitable and if the mine fails to make suitable provision for it the investor should recognize the fact and in his valuation of the property provide for this moral certainty.

It is essential that the investor appreciate the difference between capital expenditure and operating charges. Unless there be a substantial enlargement of operations the former should cease when the property reaches the productive stage.

At a producing steam-shovel mine the erection of a coarse crushing plant to handle boulders—thereby eliminating block holing—is not a capital but an operating charge. The installation of improved grinding, concentrating or cyaniding equipment to replace antiquated or relatively inferior units is likewise an operating charge. The substitution of an oil or hydro-electric power plant for a coal or wood-burning installation comes within the same category. All these substitutions are presumably being made for economic reasons, and future operations are expected to benefit thereby. In all cases we assume that no substantial enlargements are involved; it simply implies an endeavor to keep pace with the best practice and benefit economically from the advances in the arts.

Possibly a concrete example which has come under my observation may prove of interest. A gold mine has for a number of years been declaring operating profits of about $100,000 per annum. It is today a deep property, but the bottom levels look well and there are about 5 years of reserve ore in sight at the present rate of milling. The property is worked through a vertical shaft which started in the hanging wall of the vein, passed through the ore channel at about the 300-ft. level, and is today at the bottom several hundred feet in the foot wall. The vein has flattened somewhat with depth and the main oreshoot has developed a pitch away from the shaft. Therefore, at the lowest level they are faced with several hundred feet of crosscut, plus several hundred feet of driving on an ore channel, showing only occasional patches of payable material, before the main oreshoot is reached. These patches have, however, influenced the management in following this scheme of development rather than using a diagonal crosscut. For the last 500 ft. of depth the vein has shown a constant dip and the main oreshoot a fairly regular pitch. It has been decided that a new shaft is economically desirable and that fully equipped it will cost about $250,000 or say 2½ years' earnings. These financial requirements are being met through the issue of additional shares—or in other words it is considered a capital charge. In reality it is nothing more or less than a replacement, an operating charge. The present shaft is well-equipped and serviceable, but by virtue of the conditions outlined is rendered economically unfit.

The query may be raised as to the object of this technical differentiation. Granted that the mine will benefit economically by these improvements the question arises as to what is gained by properly classifying the expense. The outlay has been deemed desirable and is authorized; does it matter, therefore, whether it is a capital or an operating charge? The answer is simple. If it has not been provided for gradually in an operating way and comes rather in the nature of an avalanche, the obligation will presumably be met by either or both of (*a*) the diverting of a large part if not all of the dividends for a period of time, or (*b*) the raising of additional capital through an increase in the issued shares, or in bonds, notes and similar obligations. Even granted this, one may properly inquire as to the practical value of these contentions. In reply to which I can only refer to a prior statement wherein I indicated that, on balance, the investor in the average mine was not justified in expecting that more than 70 to 80 per cent. of the anticipated or declared earnings would be paid as dividends—the 20 to 30 per cent. difference being absorbed by various more or less standard charges and by the ordinary vicissitudes of mining. If he enters into mining upon that basis, he will have prepared himself for the practically inevitable curtailment of dividends, or their dilution through future stock increases.

The experienced mining investor who reads carefully the annual and interim reports of the company, analyzes the financial statements and generally informs himself through engineers or from outside channels as to conditions at the property, should, by employing business judgment, be able to act intelligently in the matter of his investment. It requires, however, no stretch of the imagination to conceive of a report which is superficially good but which fails to stand analysis and excites suspicion as to the intrinsic soundness of the undertaking.

METHODS EMPLOYED TO TEMPORARILY INCREASE DIVIDENDS

The methods which can be employed to make a temporarily good showing—at the ultimate expense, however, of the property—are numerous. A few of them may prove interesting.

Selective Mining.—Selective mining, whereby ore of unwarranted high value is mined in such a manner as to make lower-grade but payable ore incapable of future profitable extraction. To cite an example: A gold mine of which I have knowledge shows in its payable sections a vein whose average width is 8 ft., assaying $12 per ton.

At times a high-grade streak, which may run for fair distances is encountered which assays about $20 across 3 ft.—the remaining 5 ft. of vein material averaging about $8 per ton. Recoveries are about 90 per cent. and total costs in the neighborhood of $6 per ton. The mining methods employed and the physical nature of both the vein material and the enclosing rocks are such that ore not removed in the course of regular operations, cannot, unless of high grade, be profitably recovered thereafter. The possibilities for selective mining to the ultimate detriment of the property will be apparent.

This practice should not be confused with the recognized procedure of sweetening mill returns by drawing upon certain high-grade sections of the mine. For instance, a gold-silver mine in Mexico with which I was connected presented two distinct types of ores occurring in different veins. The first or milling grade was semi-oxidized and averaged $9 to $11 per ton; the second was to all intents and purposes sulphide and averaged $30 to $40 per ton. Operating costs were about $4.50 per ton and in order to maintain stability of production monthly profits were kept at a fairly constant figure. To achieve this it was necessary to draw on the high-grade orebody in varying amounts for 2 or 3 days toward the end of the month.

This procedure was quite legitimate. The tonnage and value of the two types of ores were reported separately in the annual estimates and altogether the combination proved highly desirable both from the point of view of the shareholder and of the management.

Reduced Development.—Reduction in the development footage or in preparatory work incidental to stoping is common. Unless the general outlook for ore improves very materially, and provided the methods of estimation are not changed, these curtailments will in time automatically be reflected in the ore reserves. If any doubt whatever as to the intentions of the management is entertained, the details which go to make up the development returns should be closely compared from year to year. It seems unnecessary to amplify this by stating that drifting or crosscutting is cheaper than shaft sinking, that raising is cheaper than sinking winzes, etc., and that since all of these and other items enter into the development scheme of most mines, the total footage accomplished is not necessarily a criterion by which to judge.

Some years ago I had occasion to investigate a property on the Gold Coast of West Africa. The mine in question was worked through a shaft and opened by levels at 100-ft. intervals with other underground development. Stoping was done by an overhand system, a stope drive being run about 8 ft. above the back of the level with box holes at 25-ft. intervals and raises through to the next level every 200 ft. Obviously the cost of at least the stope drive and box holes was chargeable to stoping and nothing else. The management at the time of my visit claimed substantial underground cost reductions over the previous régime. The details of development footage were normal, the scale of production had not changed and the condition of the mine was fair. Further investigation developed the fact, however, that the newly installed management was classifying as development all stope drives, short raises (subsequently used as box holes) and long raises between levels. The result is obvious. True development was far below normal, and it was only a question of time when the ore reserves would have reflected the condition. Furthermore, the underground costs, if properly allocated, showed no reduction whatever, but rather an increase over those of the preceding management.

Employment of Unsuitable Mining Methods.—I know of no method of mining which has for its object the extraction of all the ore undiluted with waste. Some of the recently developed caving systems probably do not yield an underground recovery of over 80 per cent.; yet, operating on low-grade ores, these methods, by virtue of their low cost per ton mined, are highly desirable. In other words, the method and cost of mining and the underground recovery should, where possible, be economically balanced.

A concrete example is suggested by a district in Mexico which is characterized by orebodies of considerable length with widths up to 100 ft. The enclosing rocks are usually slate. The best underground practice of the region calls for square-set timbering and waste filling. This is expensive, but creates underground security and yields a high ratio of extraction. One of the larger properties of that locality had for some time been reporting suspiciously low underground costs due to so-called revolutionary methods of mining. These methods became public property along with the collapse of most of the large stopes, the loss of several lives and great quantities of ore. All of which was accompanied by heavy depreciation in the market value of the company's shares.

Lack of Maintenance of Equipment.—The maintenance of the plant and equipment in a good state of repair and efficiency is essential. Without physical inspection it is practically impossible to determine the degree to which this essential is being carried. Needless to say it is an item of the first importance.

It seems unnecessary to cite others of the great array of contingencies. After all, the shareholder looks to the directors, and the directors look to the manager for results. If a shareholder has doubts as to the integrity or intentions of the management or directorate, the wise policy is to dispose of his interest in the concern provided this can be done without loss; otherwise the cost of special information may be warranted and if conditions at the property are radically wrong some pressure may thereupon be brought to bear looking toward a remedy.

CHAPTER V

DETERMINATION OF THE VALUE OF A MINE OR MINING SHARE

All mines are wasting assets, therefore the sum total of the dividends is required to return the capital plus interest over the period of distribution. This obviously entails an estimate of life, *i.e.*, the period of years during which the dividends are presumed to be distributed. Having two fundamental factors: (*a*) the life in years, and (*b*) the average annual dividend over this period, the value of the shares is capable of calculation. Tables have been prepared which assist in rapid valuation, but to permit of their application we must predetermine the rate of interest which is required, having regard to the risk involved. This is largely a matter of individual opinion.

In defining this word "interest" I refer only to the direct return to which the investor considers himself entitled. But in addition to this, as will be shown, there is a further sum presumed to be included in the annual dividends, which if re-invested and compounded at a stated per cent. will retire the principal at the end of the life period.

Large American Porphyry Copper Mines.—The total ore which the mine may ultimately yield is known within relatively close limits. The values are quite regularly disseminated throughout the deposit, which obviates sweeping changes in the grade of the material mined, and the properties are already operating at a wholesale rate. Therefore, in so far as these items are concerned, there is but little chance of wide variation. The other factors which may vary over broader ranges are: (*a*) the market value of the product, *i.e.*, copper, (*b*) metallurgical improvements, and (*c*) operating charges. Shares of this type are sometimes considered on a 7 per cent. interest basis. The same remark might apply to some of the large low-grade gold mines like the Homestake.

Rand Mines.—As a type with a somewhat greater risk I should take some of the larger Rand mines of South Africa. Consider a property which has operated successfully for 5 years, has assured ore developed to last an additional 5 years at the present rate of crushing, and has undeveloped but contiguous holdings which, on the basis of factors obtained as a result of past work, are expected to yield sufficient ore to supply the mill for a further 10 years. I can mention several mines coming within this category, where the expectation for ore in unexplored areas is fortified by the experience gained in adjoining mines. Having regard to all this and to the comparative uniformity of the Rand banket both from the point of view of values and tonnage, shares coming within this type are often purchased on a 10 per cent. interest basis.

Speculative Mines.—In the third class I should include those mines which are decidedly more speculative in character. Take for instance a mine whose orebodies are relatively high-grade and narrow and occur in a fissure vein. We will assume that the property has paid varying rates of dividends over a period of 3 years and that there are 3 years' reserve of ore in sight at the present rate of milling. The appearance in the bottom is normal, and experience in the locality indicates that the chances are fair for considerable continuity of the orebodies, principally with depth. I hesitate to indicate what might constitute an adequate interest return in such a case—it would certainly be considerably more than 10 per cent., but how much more would depend on local conditions. In any event it would probably be classified as speculative to a pronounced degree.

Interest, Dividend and Discount Tables.—The tables, to which previous reference has been made, follow. The general arrangement is from Hoover's "Principles of Mining," supplemented by further data obtained from the complete tables of Inwood and Hoskold.

TABLE I.—THE PRESENT VALUE OF AN ANNUAL DIVIDEND, INCLUDING THE REPLACEMENT OF CAPITAL BY REINVESTMENT OF AN ANNUAL SUM AT 4 PER CENT.

Years	6 Per cent.	7 Per cent.	8 Per cent.	9 Per cent.	10 Per cent.	15 Per cent.	20 Per cent.
1	0.94	0.93	0.92	0.92	0.91	0.87	0.83
2	1.82	1.78	1.75	1.72	1.69	1.56	1.45
3	2.63	2.56	2.50	2.44	2.38	2.13	1.92
4	3.38	3.27	3.17	3.07	2.98	2.59	2.30
5	4.09	3.93	3.78	3.64	3.51	2.99	2.60
6	4.74	4.53	4.33	4.15	3.99	3.32	2.85
7	5.36	5.09	4.84	4.62	4.41	3.62	3.06
8	5.93	5.60	5.30	5.04	4.79	3.87	3.24
9	6.47	6.08	5.73	5.42	5.14	4.09	3.40
10	6.98	6.52	6.12	5.77	5.45	4.29	3.53
11	7.45	6.94	6.49	6.09	5.74	4.46	3.65
12	7.90	7.32	6.82	6.39	6.00	4.62	3.75
13	8.32	7.68	7.13	6.66	6.24	4.76	3.84
14	8.72	8.02	7.42	6.91	6.46	4.89	3.93
15	9.09	8.34	7.79	7.14	6.67	5.00	4.00
16	9.45	8.63	7.95	7.36	6.86	5.11	4.07
17	9.78	8.91	8.18	7.56	7.03	5.20	4.13
18	10.10	9.17	8.40	7.75	7.19	5.29	4.18
19	10.40	9.42	8.61	7.93	7.34	5.37	4.23
20	10.68	9.65	8.80	8.09	7.49	5.45	4.28
21	10.95	9.87	8.99	8.24	7.62	5.52	
22	11.21	10.08	9.16	8.39	7.74	5.58	
23	11.45	10.28	9.32	8.52	7.85	5.64	
24	11.68	10.46	9.47	8.65	7.96	5.70	
25	11.90	10.64	9.61	8.77	8.06	5.75	
26	12.11	10.80	9.75	8.88	8.16	5.79	
27	12.31	10.96	9.88	8.99	8.25	5.84	
28	12.50	11.11	10.00	9.09	8.33	5.88	
29	12.68	11.25	10.11	9.18	8.41	5.92	
30	12.85	11.38	10.22	9.27	8.49	5.95	
31	13.01	11.51	10.32	9.36	8.56		
32	13.17	11.63	10.42	9.44	8.62		
33	13.31	11.75	10.51	9.51	8.69		
34	13.46	11.86	10.60	9.59	8.75		
35	13.59	11.96	10.67	9.65	8.80		
36	13.72	12.06	10.76	9.72	8.86		
37	13.84	12.16	10.84	9.78	8.91		
38	13.96	12.25	10.91	9.84	8.96		
39	14.07	12.34	10.98	9.89	9.00		
40	14.18	12.42	11.05	9.95	9.05		

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3,99,6 0
2,394 0

TABLE I.—THE PRESENT VALUE OF AN ANNUAL DIVIDEND, INCLUDING THE REPLACEMENT OF CAPITAL BY REINVESTMENT OF AN ANNUAL SUM AT 4 PER CENT.—(*Continued*)

Years	6 Per cent.	7 Per cent.	8 Per cent.	9 Per cent.	10 Per cent.	15 Per cent.	20 Per cent.
45	14.65	12.78	11.33	10.18	9.24		
50	15.03	13.06	11.55	10.36	9.39		
55	15.33	13.29	11.73	10.50	9.50		
60	15.58	13.47	11.87	10.62	9.60		
70	15.94	13.75	12.09	10.78	9.73		
80	16.18	13.92	12.22	10.89	9.82		
90	16.34	14.04	12.31	10.96	9.88		
100	16.45	14.12	12.38	11.01	9.92		

Assuming a gold mine, which is today productive, we estimate that it will continue to pay dividends of $2 per share per annum over a period of 15 years, *i.e.*, the calculated life of the mine. We will furthermore assume that the investor considers that the risk involved entitles him to a return on his money at the rate of 10 per cent. per annum together with a further sum which if re-invested at 4 per cent. per annum compound interest will return the principal at the end of the life period, or in short on a 10 per cent. and 4 per cent. basis. This being a 4 per cent. table the only two factors with which we are concerned are: (*a*) the life 15 years, and (*b*) the rate of yield 10 per cent. From the table we therefore obtain the factor 6.67. The "present value" of the share is therefore $13.34, *i.e.*, the annual dividend $2 multiplied by the factor 6.67. An analysis of this result gives $1.33 as the annual interest at 10 per cent. and the remaining $0.67 if re-invested each year at 4 per cent. and compounded would amount to $13.34 at the end of 15 years.

As another example we may assume that a large productive low-grade copper mine, with copper worth 14 cts., can earn $3 per share per year at the proposed rate of crushing over its reasonably assured life of 20 years. We will furthermore assume that 80 per cent. of these earnings or operating profits are likely to be paid as dividends, *i.e.*, $2.40 per share per year. Having regard to all the foregoing, we assume that the investor will be interested in this share on a 7 per cent. and 4 per cent. basis. From the table, therefore, the "present value" of this share is $23.16.

Table II.—Number of Years of Life Required to Yield 20 Per Cent Interest, and in Addition to Furnish Annual Instalments which, if Re-invested at 4 Per Cent. will Return the Original Investment at the End of the Period

Annual rate of dividend, per cent.	6 Per cent.	7 Per cent.	8 Per cent.	9 Per cent.	10 Per cent.	15 Per cent.	20 Per cent.
7	41.0						
8	28.0	41.0					
9	21.6	28.0	41.0				
10	17.7	21.6	28.0	41.0			
11	15.0	17.7	21.6	28.0	41.0		
12	13.0	15.0	17.7	21.6	28.0		
13	11.5	13.0	15.0	17.7	21.6		
14	10.3	11.5	13.0	15.0	17.7		
15	9.4	10.3	11.5	13.0	15.0		
16	8.6	9.4	10.3	11.5	13.0	41.0	
17	7.9	8.6	9.4	10.3	11.5	28.0	
18	7.3	7.9	8.6	9.4	10.3	21.6	
19	6.8	7.3	7.9	8.6	9.4	17.7	
20	6.4	6.8	7.3	7.9	8.6	15.0	
21	6.0	6.4	6.8	7.3	7.9	13.0	41.0
22	5.7	6.0	6.4	6.8	7.3	11.5	28.0
23	5.4	5.7	6.0	6.4	6.8	10.3	21.6
24	5.1	5.4	5.7	6.0	6.4	9.4	17.7
25	4.9	5.1	5.4	5.7	6.0	8.6	15.0
26	4.7	4.9	5.1	5.4	5.7	7.9	13.0
27	4.5	4.7	4.9	5.1	5.4	7.3	11.5
28	4.3	4.5	4.7	4.9	5.1	6.8	10.3
29	4.1	4.3	4.5	4.7	4.9	6.4	9.4
30	3.9	4.1	4.3	4.5	4.7	6.0	8.6

The application of the table is simple. A share pays 25 per cent. per annum on the purchase price. Required the number of years life at this dividend rate to amortize the original investment and meanwhile yield say 10 per cent. The solution in this instance is 6 years.

TABLE III.—COMPOUND DISCOUNT TABLE SHOWING THE PRESENT VALUE OF $1 PAYABLE IN 1 TO 30 YEARS, INTEREST BEING TAKEN AT 5 TO 10 PER CENT.

Years	5 Per cent.	6 Per cent.	7 Per cent.	8 Per cent.	9 Per cent.	10 Per cent.
1	$0.952	$0.943	$0.934	$0.926	$0.917	$0.909
2	0.907	0.890	0.873	0.857	0.842	0.826
3	0.864	0.840	0.816	0.794	0.772	0.751
4	0.823	0.792	0.763	0.735	0.708	0.683
5	0.783	0.747	0.713	0.681	0.650	0.621
6	0.746	0.705	0.666	0.630	0.596	0.564
7	0.711	0.665	0.623	0.583	0.547	0.513
8	0.677	0.627	0.582	0.540	0.502	0.467
9	0.645	0.592	0.544	0.500	0.460	0.424
10	0.614	0.558	0.508	0.463	0.422	0.386
11	0.585	0.527	0.475	0.429	0.388	0.350
12	0.557	0.497	0.444	0.397	0.356	0.319
13	0.530	0.469	0.415	0.368	0.326	0.290
14	0.505	0.442	0.388	0.340	0.299	0.263
15	0.481	0.417	0.362	0.315	0.275	0.239
16	0.458	0.394	0.339	0.292	0.252	0.218
17	0.436	0.371	0.316	0.270	0.231	0.198
18	0.415	0.350	0.296	0.250	0.212	0.180
19	0.396	0.330	0.276	0.232	0.194	0.164
20	0.377	0.311	0.258	0.215	0.178	0.149
21	0.359	0.294	0.241	0.199	0.164	0.135
22	0.342	0.277	0.266	0.184	0.150	0.123
23	0.325	0.262	0.211	0.170	0.138	0.112
24	0.310	0.247	0.197	0.158	0.126	0.102
25	0.295	0.233	0.184	0.146	0.116	0.092
26	0.281	0.220	0.172	0.135	0.106	0.084
27	0.268	0.207	0.161	0.125	0.098	0.076
28	0.255	0.196	0.150	0.116	0.090	0.069
29	0.243	0.184	0.140	0.107	0.082	0.063
30	0.231	0.174	0.131	0.099	0.075	0.057

The second example under Table I may be extended to make use of this table. Assume that, at the proposed rate of crushing, dividends of $2.40 per share per year will be paid over the calculated life of the mine, namely 20 years. On a 7 per cent. and 4 per cent. basis the "present value" of these dividends is $23.16. If, however, we estimate that 4 years will be required before the mine reaches the dividend-paying stage, our money being meanwhile considered as worth 7 per cent., we have the discounted "present value" of these dividends as $23.16 multiplied by 0.763 or $17.67.

The future operations of a mine can rarely be predicted with the fine degree of precision required to make unreserved use of these and similar tables. Their usefulness is, therefore, confined to establishing a common basis of comparison—but the fact should not be overlooked that the underlying factors essential to the application of these tables are liable to rather wide interpretation. The outlook for additional ore, or an increased value of the product of the mine—if other than gold—must not be ignored. In other words, the personal equation is important. Predictions as to the ultimate performance of a mine are at the best educated guesses, and are consequently subject to considerable variation.

Some engineers, when dealing with a speculative type of mine such as a relatively high-grade fissure vein, prefer to ignore "present values" and content themselves with inquiring into the net value of the reasonably assured assets and their relation to the market value of the concern. These will be made up principally of net cash or other marketable assets capable of easy realization, and of ore reserves. The equipment of a worked out mine is worth but little. The balance sheets will indicate the financial position of the company, and the estimates of tonnage together with the probable net realizable value thereof, based on the particular bookkeeping methods employed, will give the value of the ore reserves. Some engineers have gone on record to the effect that provided the bottom of the mine is normal, and there are no disquieting features, and the net value of the reasonably assured assets represent 70 per cent. of the market value of the mine, it would indicate a desirable purchase.

To cite a concrete example let us assume that the market value of a gold mine operating on a fissure vein is $1,000,000. The average grade of ore yields a working profit of $4 per ton and experience has shown that about 75 per cent. of this or $3 per ton is paid in dividends. The net quick assets are $100,000—and so far as can be determined these are not earmarked for any unusual purpose. The ore reserves are estimated at 200,000 tons of average grade and the indications for continuation of the orebodies both laterally and in depth are normally good. The mine has had a fairly prosperous history. On the basis of its past record the dividend value of the ore reserves would be $600,000, in addition to which the net quick assets of the company are $100,000—making the total of reasonably assured assets $700,000 or 70 per cent. of the market value of the mine. Provided the annual dividend or rate of yield is adequate for the type of risk involved, the market valuation of the mine might be considered as representing a fair speculation.

It will be obvious that in the case of a mine which is to all intents and purposes exhausted the ratio must be considerably higher. For instance, in a property where the deposits had been definitely bottomed, and with no chance for lateral extension we should be faced solely with the realization of the estimated reserves and since these are required not only to redeem the market value of the mine, but interest as well over the period of extraction, the realizable value of the assets should exceed the market value of the property. This, however, is an extreme case.

CHAPTER VI

Valuing Mine Products

One of the factors which has thus far been referred to in but a general way is the market value of the product of the mine. Gold is the sole metal which is without direct market fluctuation; indirectly it fluctuates in price as measured by its purchasing power. The prices of all other metals vary in accordance with the law of supply and demand, and other factors which need no discussion here.

The appraisal of a mine necessitates an estimation of the probable market value of its product over the period of production. That this value, if other than gold, will vary within wide limits, depending on factors incapable of predetermination, is a foregone conclusion. We are faced, therefore, with the necessity of arriving at some value for these products which will we believe approximate the average over a period of time. In attempting to gage the future, such evidence as is furnished by statistics is indicative but not conclusive. In other words, one should be influenced by the industrial outlook and the peculiar conditions of the problem under consideration. A blind adherence to the teachings of statistics may, on balance, prove justifiable, but these same statistics if tempered with business judgment and common sense should prove more instructive.

Supply and demand will, over an extended period, prove the controlling factors, but manipulation may cause waves of unsettlement. Of the metals to be reviewed silver, as a monetary standard, may be subject to influences from which the remainder are immune.

The metals with which I propose to concern myself are copper, lead, zinc, tin and silver. The standards of comparison which prevailed 20 years ago are interesting as furnishing collateral evidence of the growth in demand, but in most cases I should hesitate to give them too much weight in attempting to gage the future.

The growth in the world's production of these metals over the past 20 years has, in some cases, been large as the following comparisons will show, and since production presumably implies consumption, I shall not confuse the issue by presenting figures covering the latter.

PRODUCTION

Annual average for 5 years ended Dec. 31	Tons of 2,000 lb.				Ounces (Troy)
	The world		Europe and America	The world	
	Copper(*a*)	Lead(*a*)	Zinc(*a*)	Tin(*b*)	Silver(*c*)
1915	1,075,000	(*d*)1,273,000	(*d*)1,049,000	127,000	230,300,000
1910	866,000	1,147,000	830,000	112,000	209,200,000
1905	682,000	1,027,000	644,000	100,000	175,200,000
1900	486,000	861,000	508,000	84,000	179,200,000

(*a*) *Mineral Industry* for 1915 and previous years.
(*b*) *Mineral Industry*, *Metal Statistics* and "Tin" by W. H. Goodchild.
(*c*) *Mineral Industry*, and *Enginering and Mining Journal.*
(*d*) Three years only, 1914 and 1915 figures not available.

In connection with the foregoing the New York selling prices over corresponding periods will prove of interest.

NEW YORK PRICES

Annual average for 5 years ended Dec. 31	Cents per pound				Cents per ounce
	Electrolytic copper(*a*) (*b*)	Lead (*b*)	Zinc (*c*)	Tin (*c*)	Silver (*d*)
1915	14.91	4.35	(*e*)7.47	41.54	55.28
1910	15.64	4.78	5.68	34.35	57.99
1905	14.39	4.33	5.15	28.34	57.20
1900	13.74	3.84	4.56	19.93	61.80
20 years average	14.67	4.32	5.71	31.04	58.07

(*a*) From 1896 to 1905 inclusive, Lake copper prices are used and average about 1/10 ct. per pound higher than electrolytic.
(*b*) *Mineral Industry* and *Metal Statistics*, 1915.
(*c*) *Metal Statistics*, 1915, and *Engineering and Mining Journal.*
(*d*) *Mineral Industry.*
(*e*) This is largely due to the extraordinarily high average price of 13.23 cts. per pound which prevailed for zinc during 1915.

An attempt to appraise the probable future of the metals would under normal conditions be influenced by: (*a*) the probable demand which is in a measure reflected in the ratio of increase in production over the period of years, (*b*) the ability of known deposits to meet this demand together with the likelihood of effecting new discoveries of a substantial nature, and (*c*) the bearing which metallurgical and other improvements or discoveries may have on the direct and indirect production of these metals.

The unparalleled destruction arising out of the existing great war, the uncertainties which surround its ultimate scope and termination, and the world-wide problems—social, financial and commercial—which require solution upon its conclusion, introduce factors in the application of which there is no precedent. With the future so obscured an estimate as to the average metal prices which are likely to prevail over the next 10 years would, at the best, be a mere hazard. Having regard to the foregoing, therefore, I shall, for the purpose of this discussion, use the figures considered as conservative under normal or pre-war conditions, namely, the following average New York prices per pound: copper 14 to 15 cts.; lead 4.25 to 4.50 cts.; zinc 5 to 5.50 cts.; tin 35 cts.; and silver not in excess of 55 cts. per ounce.

CHAPTER VII

WORLD'S GOLD PRODUCTION WITH A REVIEW OF THE WORLD'S GREATEST GOLD FIELD

The increase in the world's gold production over a period of 20 years is shown in the following table:

Years	Average annual production[1]
1911 to 1915 inclusive....................	$463,788,000
1906 to 1910 inclusive....................	434,884,000
1901 to 1905 inclusive....................	323,333,000
1896 to 1900 inclusive....................	261,347,000

Comparative statistics of the principal gold-producing countries covering the past 2 years follow:

	1915		1914	
	Total production[1]	Percentage of world's production	Total production[1]	Percentage of world's production
The world......	$470,980,000		$451,582,000	
Transvaal.......	188,398,000	40.0	173,176,000	38.3
United States...	98,891,000	20.9	94,532,000	20.9
Australasia......	44,368,000	9.4	45,659,000	10.1
Russia and Siberia	26,750,000	5.7	26,763,000	5.9
Mexico.........	16,975,000	3.6	18,185,000	4.0
Canada.........	15,875,000	3.4	15,925,000	3.5

The foregoing comparison establishes the unquestioned supremacy of the Transvaal of South Africa as a gold producer, therefore some space can profitably be devoted to a review of the Witwatersrand—hereafter to be referred to as the Rand—which produces over 95 per cent. of the Transvaal gold.

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[1] *Engineering and Mining Journal*, Jan. 8, 1916.

The Rand

The Rand is the greatest gold field the world has ever known. Embracing as it does roughly 60 miles of practically continuous reef, with companies working the outcrops, but principally the deep levels and producing in the aggregate over $180,000,000 or nearly 40 per cent. of the world's gold per annum, it requires no stretch of the imagination to realize that its equivalent is not likely to be found.

Gold was first reported about 1887 and up to the end of 1915 this field had produced over two and a quarter billion dollars in bullion. The outcrop of the reef, although prominent and fairly continuous, had prior to 1887 been overlooked as a possible source of gold. It is a conglomerate—locally called banket—the gold being principally confined to the cementing matrix.

The history of the Rand is one of declining yields, increased rates of output and correspondingly reduced costs. During the first few years of its life the yield was well in excess of $15 per ton whereas in 1915 the yield from 28,315,000 tons crushed was $6.56 per ton. It is, however, only since the Boer war (1899–1902) that pronounced strides toward large tonnage and low costs have been made. Therefore, comparisons[1] covering the post-war period will not be out of place.

Year	Tons milled	Yield per ton	Working cost per ton	Working profit per ton (Based on realized value of gold)
1902	3,417,000	$10.50	$6.44	$4.13
1906	13,572,000	8.62	5.54	3.13
1910	21,433,000	7.12	4.40	2.62
1914	25,702,000	6.63	4.27	2.25
1915	28,315,000	6.56	4.36	2.10

Once the magnitude of the gold field was realized its control gravitated into strong hands. The most powerful of these holding and directing concerns is the Central Mining and Investment Corporation founded by Sir

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[1] *Annual Report*, Transvaal Chamber of Mines, 1915.

Julius Wernher. The wide scope of this company's control will be realized if we note that among other things it directs the affairs of 15 companies who in 1915 distributed $19,077,100 in dividends out of the total of $38,097,080 paid by the entire Rand. Thereafter follows The Consolidated Mines Selection Co., The Consolidated Goldfields of South Africa, S. Neuman & Sons, The General Mining and Finance Corporation, Goerz & Co. and others.

In other words, centralized control is today the keynote of the Rand. These financially powerful holding concerns, with their strong financial connections, great resources and affiliations have to a large extent rendered possible the enormous financing required for deep-level mining. The claim boundaries of the Rand companies are defined by vertical planes, there are consequently both outcrop and deep-level mines. At this juncture it may be noted that on the deep-level properties vertical shafts 3,000 to 4,000 ft. in depth are the rule rather than the exception. A 3,500-ft. shaft when equipped can be considered as costing $1,000,000 to $1,250,000 and two of these are usually required. Shaft sinking and equipment, underground development and preparation, general surface plant and a mill to treat 400,000 to 600,000 tons per year can be assumed as likely to cost between $5,000,000 and $7,000,000.

The Rand banket by virtue of its remarkable continuity and relative steadiness of grade has offered inducements for equipment and development on a scale never before undertaken on deposits of this type. The huge sums required for shaft sinking and development on a deep-level mine—all forthcoming on the strength of a few bore holes and the collateral evidence of adjoining mines—might not be obtained with facility in other districts. But on balance they are on the Rand justifiable and remunerative.

A comparison of the performance of this gold field as a whole for the past 2 years follows:[1]

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[1] *Annual Report*, Transvaal Chamber of Mines, 1915.

	1915	1914
Tons milled	28,314,579	25,701,954
Yield	$186,324,960	$170,622,170
Yield per ton	$6.56	$6.63
Working profit	$59,655,310	$57,768,485
Working profit per ton	$2.10	$2.25
Dividends	$38,097,080	$40,367,180

Over the past few years, in round figures, nearly one-quarter of the gold produced from the Rand has been paid to shareholders as dividends. During 1914, 20 of the most successful operating companies having an issued capital of $93,408,520 paid dividends aggregating $27,312,800 equal to an average of 29.2 per cent. on the capital. During this same year the total dividends distributed by all the Rand mines was $40,367,180.

The probable life of this most important gold field, which to the end of 1915 has produced 280,000,000 tons of ore, has been the subject of several investigations.

The Dominions Royal Commission sitting in South Africa accepted the technical opinions of four engineers of prominence, who, after an exhaustive inquiry and investigation, reported in 1914 that the producing mines can still furnish 550,000,000 tons of ore; that the present rate of crushing, namely 28,000,000 tons per year, can be maintained until 1920; and that by 1930 the annual tonnage will be one-half of what it is now.

Another prominent engineer, acting for the government, stated in 1914:

1. The producing mines can still furnish 587,000,000 tons of ore.

2. By 1924, 25 mines which in 1914 produced at the rate of $50,000,000 per annum will cease operation.

3. By 1934, 13 additional mines which in 1914 produced at the rate of $52,500,000 per annum will cease operation.

4. By 1944, 9 mines which in 1914 produced at the rate of $37,500,000 per annum will cease operation.

These two independent opinions are substantially in agreement. They both confine their estimates to mines now (1914) producing; but new mines come into production from time to time which may tend to counteract this reduction in output.

In addition to this, however, there are possibilities of undeveloped areas along the outskirts—principally on the dip. It is stated that out of 114,500 possible claims untested and not now owned by producing mines 31,400 may prove exploitable. These may contain 600,000,000 tons as compared with:

280,000,000 tons mined to the end of 1915.

587,000,000 tons estimated yet to be extracted from mines now (1914) operating or about to operate.

Whether these possibly exploitable outlying claims will ever be worked depends on:

(*a*) The probable assay value of their ores as disclosed by drilling and future deep-level mining.

(*b*) The depth to which mining can economically be carried.

(*c*) The attitude of the government as regards very deep-level mining and assistance from the government in the direction of decreased taxes and duties, combined, when necessary, with a more rational leasing basis.

Local Conditions on the Rand.—The dip of the reef may vary from 80° (nearly vertical) to less than 5° (practically horizontal). The width of the gold-bearing reef may vary from 10 in. to more than 10 ft., but since a stoping width of 4 to 6 ft. is required, this latter is one of the determining factors in the matter of payability.

The ore reserves are calculated on a given stoping width. The gold-bearing reef may be considerably narrower than the total width stoped. The material mined is subjected to sorting both underground and at the surface—the usual amount sorted out ranges from 10 to 15 per cent. This, therefore, explains the varying terms "mine tons" and "mill tons" used by the engineers. The former represents the material as broken, the latter as milled.

The ore after coarse crushing and sorting usually passes under heavy-duty stamps, is ground in tube mills, classified, and leached as sands, or agitated as slimes in accordance with standard cyanide practice. Amalgamation is to some extent employed. The ultimate recovery usually exceeds 95 per cent.

The total life of a Rand mine is largely a matter of conjecture. The assured life as represented by the ore reserves is in some of the deep-level properties but a fraction of the expected life. In speculating on the total life of such a property engineers are influenced by their knowledge of the reef in that section of the Rand, by the results of neighboring operations and by bore holes or other evidence. Until a reef is thoroughly developed, however, there is no degree of certainty.

The Rand companies, among other things, report working profits, *i.e.*, the difference between the operating expense and the yield. Working profits are not dividends. On the Rand as a whole 64 per cent. of the working profit was in 1915 distributed as dividends as against 70 per cent. in 1914. The difference goes into expenditures charged to capital account, profit and other taxes, interest on and redemption of debentures, depreciation, European expenses, the phthisis fund, etc. On some mines with old plants requiring constant so-called improvements—which are really replacements of worn-out equipment—and with heavy debenture issues, but 60 per cent. or less of the working profit is paid as dividends. On other well-equipped mines with modern and relatively new plants 80 per cent. and possibly 85 per cent. may be paid. The latter is rare.

CHAPTER VIII

MINING *versus* INDUSTRIAL AND OTHER TYPES OF INVESTMENTS WITH AN ANALYSIS OF THE AFFAIRS OF TYPICAL MINING COMPANIES

Mining securities are essentially speculative, but under suitable conditions the degree of speculativeness may be reduced to a reasonable minimum—and to my mind a carefully selected mining share compares favorably with most other securities yielding a similar rate of return. Six per cent. interest or better does not go hand in hand with positive security in so far as return of capital and payment of dividends is concerned. The shares of railways, industrial companies, public utilities and others are by no means infallible standards of comparison. They are all subject to the usual contingencies of their particular field, and to the unforeseen. It is not so many years ago when the railways of the United States were held in high esteem by the investing public; thereafter followed drastic legislation with unfortunate results in so far as the market value of railway securities was concerned.

Industrial and public utility companies are influenced by some or all of the following factors, the demands of labor, legislation, destructive or normal competition, varying prices of raw material, varying demand for and value of their products and a multitude of other features, the enumeration of which will merely tend to cloud the main issue. Security, therefore, is a relative term. One has only to review the glowing but unfulfilled promises of numerous manufacturing enterprises launched within the past decade, the disillusionment which has attended the operation and growth of some steam and electric railways, and the failures among the industrial and public utility group, to realize that unfulfilled estimates and anticipations are not conspicuous by their absence in these branches of finance.

I am not putting forth these assertions in a spirit of destructive criticism. I am fully alive to the fact that a considerable portion of the wealth of any nation is invested in the securities coming under these broad classifications and that great numbers of these securities are held in the highest esteem and fully justify the confidence reposed in them. At the same time I am not prepared to admit that the better mining securities are so distinctly speculative as to be eliminated from consideration as an investment—and I hope to show that, if properly appraised, they should prove a satisfactory investment medium.

In the following pages I propose briefly reviewing the affairs of a few typical mining undertakings. I have no intention of presenting my ideas on the valuation of the various companies reviewed. I propose merely to develop a line of analysis based on the data which is available to the average shareholder. In other words, I propose eliminating, in so far as possible, the personal equation; my purpose being that of presenting concrete examples of some of the generalities reviewed during the earlier part of this discussion.

It will be obvious that an inquiry into the affairs of a mining company would be incomplete were a calculation of the "present value" of the undertaking ignored. In practically all cases, however, the present value will be the logical derivative of the company's official statements—in other words, I offer no opinion as to the significance to be attached to the fundamental figures.

It is essential that I adopt this attitude. Of the companies reviewed there is no personal indorsement or criticism involved—rather a brief analysis of the undertaking based on figures or statements which are offered as they stand.

To the engineer, or other person trained in the careful analysis of a mining company, my presentation—in view of the before-mentioned limitations which I have purposely imposed—may appear elementary. It is my belief, however, that there exists a body of interested people who, lacking the methods or facilities, are not accustomed to the close and independent investigation of mining concerns. I am in hopes that this presentation shall serve some of the purposes of this group.

NEW MODDERFONTEIN GOLD MINING CO., LTD.

Location.—Toward the eastern end of the developed Rand series, in the Transvaal, South Africa.

Capital.—The company's capitalization is $7,000,000, consisting of 350,000 shares with a par value of $20 each; all issued.

Operations.—Access to the mine is through several shafts, mainly inclines. Toward the end of 1912 a new vertical circular shaft intercepted the reef at 2,150 ft. The ore as received from the mine is subjected to sorting, the amount of waste rejected during 1914–15 was 17.1 per cent. averaging $0.98 per ton in value. The sorted product is delivered to an efficient stamp and cyanide mill which yields a recovery of 97 per cent. The following shows the operations of the company over recent years.

	Year ended June 30		
	1915	1914	1913
Tons milled	611,500	510,300	565,400
Yield per ton milled	$9.56	$9.70	$9.90
Working cost per ton milled	$3.98	$4.22	$4.97
Working profit realized	$3,417,253	$2,796,072	$2,780,425
Dividends declared	$2,187,500	$2,100,000	$2,100,000
Percentage of working profit paid as dividends	64.0	75.1	75.5
Unappropriated balance represented by net cash and cash assets	$1,765,910	$1,051,290	Not available

Ore Reserves.—The following sets forth the ore reserve position at the end of the periods cited:

	As of June 30		
	1915	1914	1913
Ore reserves, tons	6,010,800	6,334,500	4,547,000
Ore reserves, value per ton	$8.64	$8.81	$8.50

In addition to the foregoing it was estimated on June 30, 1915, that the ore partially developed in the circular-shaft section totals over 1,000,000 tons.

The ore reserves on June 30, 1915, indicate an assured life of 8.1 years at the 1915 rate of crushing (mine output 738,300 tons). In addition to this, however, there remain the unexplored portions of the company's holdings.

The mining area owned consists of 1,301 claims (the Rand mining claim is equivalent to 1.5 acres) of which 36 are north of the outcrop and consequently non-reef-bearing (the reef dipping south), leaving, therefore, 1,265 reef-bearing claims. As of June 30, 1914, we were informed that:

150 claims were exhausted and yielded 31,940 mine tons per claim.
205 claims were occupied by the estimated ore reserves, hence averaging 30,900 tons per claim.
66 claims were developed but non-payable.
844 claims remained to be developed.

The foregoing data discloses not only the average yield in tons of the claims worked out, but also the ratio of payable to non-payable areas. Unofficial calculations have been made employing these factors duly discounted for contingencies, with allowance for probable changes in the dip of the reef, and these calculations indicate that the undeveloped area as of June 30, 1915, may yield 14,000,000 tons in addition to the 6,000,000 tons assured reserves at that date, making a total of 20,000,000 tons. These calculations cannot be considered as estimates in any sense of the word, they merely represent the application of known factors, duly discounted, to an unexplored area. They may or may not be realized or they may be exceeded. The New Modderfontein property is, however, in good company—it is partially bounded by the holdings of the following successful companies with declared ore reserves averaging as follows per ton at the end of 1915: to the east, the Modder B. Gold Mines, Ltd., $9.28 (2,800,000 tons); to the south, The Modder Deep Levels, Ltd., $8.80 (2,670,000 tons); and to the southwest, Van Ryn Deep, Ltd., $8.90 (2,000,000 tons).

Dividend Value of Ore Reserves.—If to the assured mine reserves we apply the sorting factor previously referred to (*i.e.*, rejecting 17.1 per cent. of $0.98 material), there results 4,983,000 mill tons averaging $10.22 per ton. Employing a mill recovery of 97 per cent. and working costs of $3.98 per ton (both being 1915 figures) there results a working profit of $5.93 per ton equivalent to $29,549,000 when applied to the existing ore reserves. An unknown percentage of this will be paid as dividends—probably a fair assumption, under normal conditions and with the accelerated milling program to be referred to in full operation, would be say 75 to 80 per cent., giving, therefore, a resultant dividend value of the declared ore reserves as something over $22,000,000.

Plant Extensions.—In August, 1915, the directors decided to proceed with extensions of the plant to an ultimate crushing and treatment capacity of 1,100,000 tons per year. The estimated cost of this additional plant, together with underground development and other general equipment, was between $2,500,000 and $2,800,000. The work would under normal conditions occupy about 2 years. The funds required to meet this expenditure are being appropriated out of current earnings.

The assured ore reserves promise a working profit of $5.93 per ton based on the 1914–15 standards and of this an unknown percentage—arbitrarily assumed at 75 to 80 per cent.—will probably under normal conditions be paid as dividends. The ore reserves indicate a life of 8.1 years at the 1914–15 rate of crushing—but the outlook for a very material extension of this life is good. We have, therefore, the basic data—namely, average annual return and expectant life in years—essential to a calculation of the "present value" of the shares. This basic data will, however, be adjusted in accordance with the personal opinions of the investor. For instance, there is room for considerable variation of opinion not only as to the ultimate life of the enterprise on stated rates of output, but also as to the average dividend distribution over the life period. Since a program of accelerated output is in hand, the outlook is further complicated by the fact that on an enlarged scale of operations the company may decide to treat lower-grade ores, accompanied possibly by a lower operating cost.

Therefore, having regard to these indeterminate factors, calculations of "present value" with varying rates of output and life may, by way of illustration, prove interesting. It is assumed that the investor will require 10 per cent. on his investment plus further sums which if reinvested and compounded at 4 per cent. will return the original investment at the end of the life period.

ON 1914–15 MILLING BASIS

Tons to be milled per annum		610,000		
Gross milling value of ore, per ton		$10.22		
Net recovery (97 per cent. extraction), per ton		$9.91		
Working costs, per ton		$3.98		
Working profits, per ton		$5.93		
Assumed dividends (say 80 per cent. of working profit), per ton		$4.74		
Amount annually available for dividend distribution		$2,891,400		
Amount annually available for dividend distribution per outstanding share of stock		$8.26		
Ore reserves, mill tons	5,000,000	10,000,000	15,000,000	20,000,000
Life at above annual rate of crushing, years	8.2	16.4	24.5	32.7
"Present value" of above dividend at 10 per cent. and 4 per cent.	$40.14	$57.24	$66.16	$71.61

ON AN ACCELERATED MILLING BASIS

Tons to be milled per annum		1,100,000		
Assumed dividends, per ton		$4.74		
Amount annually available for dividend distribution		$5,214,000		
Amount annually available for dividend distribution per outstanding share of stock		$14.90		
Ore reserves, mill tons	5,000,000	10,000,000	15,000,000	20,000,000
Life at above annual rate of crushing, years	4.5	9.1	13.5	18.2
"Present value" of above dividend at 10 per cent. and 4 per cent.	$48.27	$77.03	$94.62	$107.58

I offer the foregoing for the benefit of those who have heretofore not had occasion to approach the value of a share from a "present value" point of view. The calculations are mathematically correct—but the final result is the derivative of a number of basic assumptions, the principal of these being the tonnage and value of ore which the area will ultimately yield, the annual rate of output, the average working cost, and the percentage of working profit which will be paid as dividends. These underlying figures will be based on: (*a*) the past operating performance of the mine; (*b*) the outlook for the future as derived from the company's official statements or from personal knowledge; (*c*) conditions in the particular field which might have some bearing on the future and (*d*) general or foreign considerations. Into the interpretation of these factors as applied to the problem in hand enters that important consideration—the personal equation. I should be surprised to find two men who, figuring independently, would be in substantial agreement on all of these basic factors. These calculations are submitted, therefore, in the nature of an example, and since I have used varying periods of life there is obviously no estimate inferred, as that is not the purpose of this discussion.

By way of review, therefore, the outstanding features which, in my judgment, should have an important bearing on an appraisal of the worth of these shares are:

1. The substantial tonnage of estimated ore reserves as of June 30, 1915, equivalent to 8.1 years of life at the 1915 rate of crushing, this being unusual for that field in view of the peculiar conditions which prevail. It is certainly conducive to security from the shareholder's viewpoint.

2. The dividend value of the declared ore reserves is probably something over $22,000,000. With the shares quoted at $85 (middle of 1916) the market value of the mine is $29,750,000. Therefore, the percentage of the market value of the mine represented by the dividend value of the declared ore reserves is about 75 per cent.—a very comfortable figure. This is a direct corollary of (1).

3. The outlook for very large additions to the existing reserves through the development of the unexplored portions of the company's holding is materially strengthened by virtue of conditions in adjoining mines.

4. The very substantial cost reductions effected—$3.98 per ton in 1915 against $4.97 per ton in 1913—is indicative of progressive able management, and lends promise to a satisfactory performance on the basis of accelerated production.

5. The yield per ton over the 3 years reviewed is substantially in agreement with the probable yield of the declared ore reserves.

6. The percentage of working profit distributed as dividends has over the 3 years reviewed averaged 73.2 per cent. In connection with this, note the substantial additions to the unappropriated balance which will be applied toward plant extensions. Therefore, the outlook for an enchanced ratio is good.

BRAKPAN MINES, LTD.

Location.—The Brakpan Mines are toward the eastern end of the developed Rand series, in the Transvaal, South Africa, and constitute a typical deep-level property.

Capital.—The mines are capitalized at $3,750,000 consisting of 750,000 shares of $5 par value each; all issued.

Operations.[1]—Two large vertical shafts, about 4,400 ft. apart, were started during the first half of 1905, and penetrated the reef about 2½ to 3 years thereafter at depths of 3,100 ft. and 3,700 ft. respectively. The mine is today operating at a vertical depth of 4,100 ft. at a distance of nearly 4 miles from the outcrop. The dip of the reef within the area developed has averaged about 7°. The company holds 1,150 claims, covering an area say 6,000 ft. by 14,000 ft., of which 441 claims had by the end of

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[1] W. L. Honnold's admirable review, "Mining Conditions on the Witwatersrand," published in 1915 in the *Transactions* of the American Institute of Mining Engineers, has been freely drawn upon.

1914 been opened, promising about 10,000 mill tons of profitable ore per claim. The lowest reef of the series is the only one of immediate importance and to this the work has been largely confined. About 50 per cent. of the reef as at present developed is of profitable grade. The ore occurrence is spotty in a large way and the orebodies are of irregular occurrence and shape—some of the larger of these have extreme dimensions of 700 by 4,000 ft.

The mill (160 stamps) started crushing in 1911. Roughly $6,000,000 had by that time been spent in drilling, shaft sinking, development and equipment. The early remoteness of the company's property made the issue speculative, but as will be seen later this great initial expenditure has been fully justified. The crushing and cyanide plant is efficient and up-to-date and yields an ultimate recovery of about 96 per cent. Of the ore received from the mine about 14 per cent. is sorted out, this rejected material averaging, according to my calculations, about $0.40 per ton.

The following shows the operations of the company over recent years:

	Year ended Dec. 31		
	1915	1914	1913
Tons milled	725,168	621,573	613,269
Yield per ton milled	$6.97	$6.91	$7.06
Working costs per ton milled	$4.50	$4.62	$4.69
Working profit realized[1]	$1,791,980	$1,417,280	$1,453,950
Dividends declared	$1,500,000	$1,125,000	$1,218,750
Percentage of working profit paid as dividends	83.7	79.3	83.8
Unappropriated balance	$407,740	$402,705	$304,380

Ore Reserves.—The following sets forth the ore reserve position at the end of the periods cited.

[1] Other miscellaneous earnings swelled this figure somewhat particularly n 1913 (roughly $75,000) as against (roughly $15,000) in 1914–15.

	As of Dec. 31		
	1915	1914	1913
Ore reserves, tons	3,017,000	2,490,000	2,242,000
Ore reserves, value per ton	$8.33	$7.13	$ 7.10

If to the 1915 estimates of ore reserves we apply the sorting factor before mentioned, namely, rejecting 14 per cent. of material assaying $0.40 per ton, we have 2,595,000 mill tons averaging $9.62 per ton. This is equivalent to 3.6 years at the 1915 rate of crushing.

We were informed however that, to the end of 1914, the 441 claims then opened up, promised a yield of 10,000 mill tons per claim, and if this factor were eventually found to apply to the total area owned (1,150 claims), we should have 11,500,000 tons. Making deductions for the tonnage crushed, leaves a prospective yield of 8,600,000 tons at the end of 1915.

The foregoing, if realized, would give 12 years' life at the 1915 rate of crushing, as compared with 3.6 years promised by the estimated ore reserve. It will be obvious from the nature of the assumptions that this prospective life of 12 years may be exceeded.

In addition to what has preceded it is anticipated that the Brakpan company will acquire from the government the right to mine under an area immediately adjoining the Brakpan holdings to the southeast and popularly known as the Brakpan reserve. This occupies over 2,000 claims, as compared with 1,150 claims of the Brakpan area proper.

It will be seen, therefore, that any opinion as to the ultimate life and yield of the undertaking offers much room for elasticity. The terms upon which the right to mine under the Brakpan reserve is acquired—if eventually done—introduce further uncertainties.

With due regard to all of the foregoing, however, an analysis of the immediate future of the company, can, with some assurance, be undertaken. If, therefore, we apply data derived from the 1915 operations to the estimated ore reserves we have the following:

Tons to be milled per annum	725,000
Gross milling value of ore, per ton	$9.62
Net recovery (96 per cent. extraction), per ton	$9.24
Working costs, per ton	$4.50
Working profit, per ton	$4.74
Assumed dividends (say 80 per cent. of working profit), per ton	$3.79
Amount annually available for dividend distribution	$2,747,750
Amount annually available for dividend distribution per outstanding share of stock	$3.66

This calculated annual dividend yield, namely, $3.66, if applied to varying tonnages will give the following "present values" on a 10 per cent. and 4 per cent. basis:

Ore reserves, tons	3,000,000	5,000,000	10,000,000	15,000,000
Life at 1915 rate of crushing, years	4.1	6.9	13.8	20.7
"Present value" of above dividend at 10 per cent. and 4 per cent.	$11.09	$16.00	$23.50	$27.74

Some outstanding features of the undertaking are:

1. With the shares quoted at $20 (middle 1916) the market value of the mine is $15,000,000. The dividend value of the assured ore reserves is $9,835,000 or 65 per cent. of the market value of the mine—a fair figure.

2. The grade and tonnage of the 1915 ore reserves show a very satisfactory increase over that of preceding years.

3. They have not of recent years treated ore of the grade called for by the 1915 reserves. If future development maintains or raises this grade it will probably be reflected in improved yields and enhanced dividends.

4. The costs for 1915 show a reduction over previous years in spite of increased operating charges due to the European conflict.

In the treatment of the future possibilities of this and the preceding mine, the complications which may be introduced by milling varying proportions and grade of development rock, mining selected portions of ore blocks heretofore classed as unpayable, effecting new discoveries within developed and payable blocks, etc., will be apparent. For the preliminary purposes of this discussion these can be ignored, but in a comprehensive analysis they must necessarily be given consideration.

LONELY REEF GOLD MINING COMPANY, LTD.

Location.—The Lonely Reef Gold Mine is 55 miles from Bulawayo, a railway point in Rhodesia, South Africa.

Capital.—The property is capitalized at $1,625,000 in 325,000 shares of $5 par value each, of which 271,007 were issued as of Dec. 31, 1915.

Type of Property.—A relatively high grade of ore occurring in a fairly persistent shoot of limited length with present stoping widths averaging say 60 in. The workings at the fifteenth level have reached a vertical depth of 1,800 ft. The tonnage of ore in reserve and the assured life is limited. The proposition is a good example of its type.

Operations.—The present company purchased the mine about 1910. Prior to that time it had been privately operated. Plans for the erection of a crushing and cyanide mill were taken in hand shortly after purchase. This plant became operative about the middle of 1911, and in 1913 was increased in size to a total of 20 stamps with tube mills and a cyanide plant.

The mine was operated through a vertical shaft to the ninth level. Below that horizon—the oreshoot having apparently pitched south—an inclined shaft was sunk,

Levels	Average length, feet	Average width, inches	Average value per ton
1st to 5th (incl.)	876	29.8	$26.50
6th to 10th	761	44.4	30.59
11th	427	48.2	11.98
12th	521	59.9	18.02
13th	424	47.3	18.66
14th(*a*)			
15th(*b*)	180	35.4	77.00

(*a*) The driving of the fourteenth level was, for operating reasons, deferred until the fifteenth had been partially completed.

(*b*) In course of development, figures as of Feb. 18, 1916.

arriving at the end of 1915 to practically the sixteenth level.

The preceding tabulation gives particulars of the orebody at various levels.

The value of the ore declined between the second and fifth levels and showed a material increase between the sixth and ninth levels. The tenth and eleventh levels showed a marked falling off in grade and a very substantial reduction in the length of the oreshoot. At about the sixth level there was a considerable increase in the width of the ore, apparently due to the deposition of a second body of rich quartz within the fissure. This in turn is believed to be related to a fault in the plane of the reef, which first made its appearance below the fourth level. The deposit is unusual, inasmuch as a portion of the ore at the thirteenth level (vertical depth 1,550 ft.) is still oxidized. The value of the ore at the fifteenth level is noteworthy, and as of May, 1916, some 40 ft. of driving on the sixteenth level gave an average of $55 over 33 in.

The following shows the operating performance of the property over recent years:

	Year ended Dec. 31		
	1915	1914	1913
Tons milled	56,910	61,590	58,903
Yield per ton milled[1]	$13.38	$15.29	$18.54
Working costs per ton milled	$8.30	$7.75	$7.83
Working profit plus miscellaneous income	$304,867	$469,670	$631,960
Dividends declared	$176,154	$250,116	$406,510
Percentage of working profit paid as dividends	57.7	53.3	64.3
Unappropriated balance	$100,295	$94,610	$69,960

[1] After deducting charges on bullion realization.

I would here call attention to the low ratio of working profit to dividends, averaging 59.2 per cent. over the 3 years reviewed. After making allowance for variations in the unappropriated balance, the difference has gone into capital expenditure, depreciation, British income and French fiscal taxes, etc., and emphasizes forcibly some of the remarks set forth earlier in this discussion.

Ore Reserves.—The following tabulation sets forth the ore reserve position at the end of the periods cited. Due to local stoping conditions the reserves are generally calculated on the reef width plus 12 in.

	As of Dec. 31		
	1915	1914	1913
Ore reserves, tons	157,279	140,042	172,557
Ore reserves, value per ton	$15.96	$15.53	$18.17

Ore required to be left as pillars and not immediately available is not included in the above.

The milling recovery is about 88 per cent. A shortage of milling water has from time to time been noticeable, and such water as is available is not always suitable for steam-generating purposes without treatment. The mine is now working at considerable depth (1,900 ft.) and ventilation is a factor of importance. The incline shaft aggravates the hoisting problem somewhat.

If to these estimates of ore reserve we apply data derived from the operations for the year 1915 we will have:

Tons to be milled per annum	57,000
Assured life at foregoing crushing rate, years	2.8
Gross milling value of ore per ton	$15.96
Net milling value of ore per ton (recovery 88.3 per cent.)	$14.09
Assumed working costs per ton	$8.30
Assumed working profit per ton	$5.79
Assumed dividends (say 60 per cent. of working profit) per ton	$3.47
Calculated amount annually available for dividend distribution (ignoring miscellaneous income)	$197,790
Amount annually available for dividend distribution per outstanding share of stock	$0.73

This mine, in its present condition, is representative of a type which does not lend itself readily to "present-value" calculations. The assured life is limited but the highly favorable developments mentioned on the fifteenth and sixteenth levels, in so far as the value of the ore is concerned, offer room for speculation. If a normal length and width of the orebody is maintained on and below those levels, these values if continued, would obviously give an entirely new complexion to the undertaking. As against this the very considerable depth (considered with respect to the area of the deposit), with attendant ventilating and hoisting complications are likely to be reflected in future working costs. The grade of ore to be milled will probably be adjusted from time to time as the grade of the ore reserves change. Such being the case, varied rates of profit can be anticipated.

In valuing a mine of this kind, the determining factors would be the dividend vlaue of the reasonably assured assets and their relation to the market value of the mine, the present and likely rate of interest yield and the speculative possibilities with depth.

UTAH COPPER COMPANY

Location.—The mines are in Bingham Cañon, Utah, U. S. A., 20 miles southwest of Salt Lake City. The mills are at Garfield, Utah, 20 miles from the mines. The concentrates are smelted at the Garfield plant of the American Smelting & Refining Co., 4 miles from the mills. All departments are interconnected by standard-gage railway.

Capital.—The authorized capital is $25,000,000 in shares of $10 par value. Outstanding Dec. 31, 1915, 1,624,490 shares.

Product.—The principal product is copper, with appreciable amounts of silver and gold. Based on the 1915 performance there is recovered 0.62 cts. in gold and silver per pound of copper produced.

Operations.—This is the premier mine of the world from the viewpoint of tonnage treated. On the basis of copper produced it is exceeded only by the Anaconda Copper Mining Co. which, however, operates an aggregation of mines.

The Utah Copper Co. employs steam-shovel mining methods almost exclusively and it is this scheme of attack which permits of the existing wholesale scale of operations. The ore is principally disseminated chalcocite in monzonite porphyry. The orebody is overlain by low-grade or valueless capping. Steam-shovel mining must be preceded by capping removal, and in order to permit of efficient operation these stripping operations must be kept well-advanced, obviously locking up large sums of money in this prepaid charge. The ore-bearing area as at present defined underlies 226 acres and while stripping operations have been conducted over 203 acres, it is estimated that 97 acres are completely uncovered. The average thickness of capping over the entire orebody is not less than 115 ft. The magnitude of these stripping operations will be evident when it is noted that prior to Jan. 1, 1916, 33,796,000 cu. yd. of capping had been removed as compared with 43,685,000 tons of ore mined.[1] On Dec. 31, 1915, the prepaid expense of stripping and some minor items was carried at over $6,000,000.

From the steam-shovel benches the ore is carried by standard-gage railway cars to the concentrating plants, 20 miles distant. Of these there are two, the Magma and the Arthur. The combined capacity of these two plants has been over 30,000 tons per day. Standard concentrating methods as developed for porphyry ores are employed, the net recovery by present methods being about 65 per cent. of the total copper content.

The concentrates which average about 20 per cent. copper are hauled by railway to the Garfield smelter. Payment is made for about 95 per cent. of the copper contained in the concentrates. In June, 1915, a new smelting contract was entered into which is more advantageous to the mine than that which was previously in force.

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[1] A cubic yard of capping may be taken as equivalent to 2 tons.

Blister copper is shipped to the Atlantic seaboard or elsewhere for refining.

The following tabulation sets forth the operations of the company over recent years:

	Year ended Dec. 31		
	1915	1914	1913
Net pounds, copper produced	148,397,006	115,690,445	113,942,834
Tons milled	8,494,300	6,470,166	7,519,392
Grade of ore milled, copper, per cent	1.434	1.425	1.247
Mill recovery copper, per cent	64.13	66.04	63.95
Net smelter recovery per ton of ore, pounds, copper	17.5	17.9	15.2
Cost per pound copper applying gold and silver credits only, cents	7.560	8.131	9.498
Net cost per pound of copper after applying miscellaneous income in Utah and B. & G. R. R. earnings, cents	6.612	7.245	8.642
Net profit for year including dividends from Nevada Consolidated holdings[1]	$17,913,481	$8,678,490	$8,513,105
Dividends paid	$6,904,082	$4,827,885	$4,747,710
Dividends paid per share	$4.25	$3	$3
Earned surplus	$23,498,073	$13,035,408	$9,708,653
Price received for copper, cents per pound	17.679	13.264	14.976

The foregoing shows a highly satisfactory improvement over the period reviewed. The increase in production and marked decrease in costs per pound of product are especially worthy of note. A striking feature of these comparative figures is the low percentage of net working profit returned to the shareholders as dividends, amounting to less than 47 per cent. over the 3 years reviewed. The difference has gone into prepaid charges, capital expenditures, depreciation, and a pronounced strengthening of the financial position of the company. The company by virtue of its wholesale operations and large output requires an extensive working capital, and provision is likewise being made to meet further large capital expenditures subsequently to be referred to.

In connection with the foregoing financial segregation it will be interesting to review stripping operations:

[1] The company holds 1,000,500 shares of the Nevada Consolidated Copper Co., equivalent to slightly over 50 per cent. of the capital stock of that company.

	Year ended Dec. 31		
	1915	1914	1913
Cubic yards capping removed	5,961,367	5,708,836	4,835,479
Cost of capping removal	$1,696,214	$2,098,287	$2,057,196
Charged to the year's operations	$637,072	$485,262	$563,954
Accumulated balance to prepaid account	$6,444,346	$5,385,203	$3,772,179

Ore Reserves.—The following tabulation sets forth the officially estimated position on Dec. 31, of the three years cited:

	1915	1914	1913
Ore reserves, fully and partly developed, tons	346,315,300	342,500,000	332,500,000
Ore reserves, copper content, per cent.	1.446	1.45	1.47
Mined to Dec. 31, tons	43,684,700	35,190,400	28,720,234
Copper content of ore, mined to Dec. 31, per cent	1.453	1.457	1.465

In connection with the foregoing I would call attention to two noteworthy features: (1) the copper content of the ore mined to date corresponds almost exactly with the average grade of the reserves, and unusual uniformity is in this respect shown over the 3 years reviewed; (2) the tonnage of ore in reserve has been increased from year to year in spite of the annual withdrawals. In this connection the company's report states that "much additional ore can and will be developed at opportune times when the work can be done without interfering with other operations."

Operating Modifications Contemplated.—Investigation has for some time been underway with a view to increasing the output and capacity of the existing mills, and developing a process for treating oxidized copper-bearing capping which has been and will be removed from the sulphide orebodies. The proposal first above outlined may among other things involve oil flotation, whereas the second may entail leaching with sulphuric acid which may be followed by electrolytic precipitation of copper.

We have already seen that the mill recoveries are, under the existing wet methods of concentration, about 65 per cent. of the copper content of the ore. As against this figure the Inspiration Copper Co. which employes oil flotation in conjunction with water concentration, reports for the 6 months ended Dec. 31, 1915, a recovery of roughly 80 per cent.—being made up of 88 per cent. of the sulphide copper in the ore and 24 per cent. of the oxide copper. Just what ultimate recovery will result at the Utah from the introduction of flotation remains to be determined. The oxide copper content of the ore will be one of the controlling factors—but a considerable improvement over present recoveries of 65 per cent. can be anticipated with confidence.

The construction of a leaching plant to treat between 2,000 and 3,000 tons of oxidized ores per day has been authorized. The experience to be gained at this installation will govern further increases in the leaching capacity. It is obvious that improvements are under way which will materially improve the value of the undertaking.

The outstanding features of all the foregoing are therefore:

(*a*) The tonnage of ore in reserve has from year to year increased in spite of substantial withdrawals for current operations. The outlook for the development of considerable additional ore is reported as good. The copper content of the ore in reserve and that mined has been unusually steady.

(*b*) The cost of production shows a remarkable decrease over the 3 years reviewed. The copper output has increased.

(*c*) The outlook for further substantial increases in the copper output are by virtue of new installations good, and further operating economies are likely.

(*d*) The financial condition of the company is strong.

(*e*) The company has, over the 3 years reviewed, paid out in dividends less than half of its net profits—the difference has gone into items previously discussed. Operating improvements, additions and prepaid charges are likely to continue to absorb considerable sums of money. Eventually the company with its present holdings will presumably reach the point of saturation in so far as large expenditures for capital or prepaid accounts are concerned.

It would appear, therefore, that Utah Copper presents as close an approach to a mining investment stock as we are likely to encounter, and such being the case "present-value" calculations should be particularly applicable. A close examination of the affairs of this company indicates that there is considerable room for elastic estimates. In the first place, the market value of the main product—copper—is subject to considerable variation, and this may be accompanied by operating curtailment or acceleration to meet the demands of the metal market. Thereafter, we are confronted with the probable financial gain due to several operating improvements or additions. The percentage of working profit which will, on balance, be paid as dividends offers further room for difference of opinion.

Since I am purposely limiting this discussion to the application of known factors, I shall necessarily ignore the effect of operating additions and improvements, which, however, we can reasonably assume will add considerably to the intrinsic worth of the enterprise. For lack of a better factor I shall assume arbitrarily that 75 per cent. of the working profit will on balance be paid as dividends—but in this connection it should be noted that the cost of production varies within, relatively speaking, a narrow field, and with rising prices of the metal the operating gain increases rapidly. Granted that charges not included in operating costs are not, in a property of this magnitude, subject to wide fluctuation the proportionate effect of an accelerated operating gain will be apparent.

Having regard to all the foregoing we can, therefore, approach the subject on the basis of the 1915 operations when applied to the ore reserves. Since shares of this type are sometimes bought on a 7 per cent. and 4 per cent. basis we will use these figures and compare them with those entailing a higher interest return:

Tons to be milled per annum	8,500,000
Grade to be milled, copper per cent	1.45
Mill recovery copper, per cent	65
Net smelter recovery per ton of ore, pounds of copper	17.9
Annual production, pounds of copper	152,150,000
Life at foregoing rate of output, years	40.7
Cost per pound copper crediting gold and silver plus miscellaneous income in Utah, plus B. & G. R. R. earnings, cents	6.6

	On basis of 14-ct. copper	Add or deduct for each cent change in price, copper
Annual earnings	$11,259,000	$1,522,000
Annual earnings per share	$6.93	$0.93
75 per cent. of annual earnings per share	$5.20	$0.70
Present value of above on 7 per cent. and 4 per cent. basis	$64.90	$8.74

Utah Copper holds, however, 1,000,500 shares of the Nevada Consolidated Copper Co. and if we were to apply to the latter concern the same method of calculation employed in the case of Utah, we should in conjunction with what has foregone have the following:

On a 7 per cent. and 4 per cent. basis	On basis of 14-ct. copper	Add or deduct for each cent change in price, copper
Present value of Utah only	$64.90	$8.74
Present value of Utah's holdings in Nevada Consolidated Co	7.38	1.29
	$72.28	$10.03

With a higher rate of interest we have:

On a 10 per cent. and 4 per cent. basis	On basis of 14-ct. copper	Add or deduct for each cent change in price, copper
Present value of Utah only	$47.22	$6.36
Present value of Utah's holdings in Nevada Consolidated Co	5.86	1.02
	$53.08	$7.38

I have already stated that the foregoing "present values" result from the application of definite premises, since this is the method employed in the preceding concrete examples. The effects of improved recoveries in the existing mills, further installations to treat capping or other material heretofore unproductive, lowered operating costs, or accelerated production are, for the purpose of this discussion, ignored, since otherwise a series of variables as well as the personal equation would, of necessity, be introduced. That the worth of the undertaking will be considerably enhanced by virtue of these improvements can, I think, be accepted with confidence.

A comprehensive analysis of this company, made with due regard to the foregoing, would deal with the financial condition of the undertaking as disclosed by the balance sheet, and treat on the outlook for copper, affecting as it will the output and profits of both this company and its subsidiary, the Nevada Consolidated Copper Co.

CONCLUSION

In the foregoing brief financial review of four specific companies I have discussed the affairs of a graduated range of mining ventures. One of these, the Utah Copper Co., represents my conception of a close approach to a mining investment and "present-value" calculations are particularly applicable, the principal variable being a fluctuating price and demand for the product, copper. The remaining companies namely, New Modder, Brakpan and Lonely Reef, have a fixed value for their product, gold, but the degree of assured life diminishes in each case and there are other variable and determining factors, so that into the application of "present-value" computations would enter, in the order named, the personal equation in an increasing degree. Furthermore, as previously mentioned, one of these concerns is representative of a type which does not lend itself readily to the "present-value" method of appraisal.

In order that I might carry out this scheme of presentation and incidentally limit my discussion to fields of which I have some knowledge, I have found it desirable to deal with some properties located abroad and since conditions which prevail on the Rand of South Africa differ in many essentials from those encountered elsewhere, some space has been devoted to a discussion of that field.

Having dealt with one mine the value of and demand for whose product is variable, I have deemed reference to examples of the other fluctuating metals as unnecessary.

In all four of these undertakings certain considerations are presaged in the reports and official statements of the companies, from which valuable inference can with some degree of safety be drawn. Beyond referring in a general way to some of the more obvious of these, I have ignored their probable financial effects and rather confined my remarks to the application of known factors. Were I not to adopt this attitude I should be required to submit a personal appraisal of the worth of the ventures reviewed, which would in turn introduce features which have purposely been omitted from any concrete discussion. The personal equation is the underlying essential of any appraisal, since mining presents none of the aspects of a cut-and-dried business, and where a specific analysis is involved I have endeavored to eliminate this feature.

Should criticism, therefore, be levied against any elementary nature of this discussion, my defense might revolve about the limitations which I have purposely imposed. I am in hopes, however, that some of the generalities which precede the specific financial examples may be of some interest to those whose principal business is not that of valuing mines, but who have occasion to investigate a mining property or share from an engineering viewpoint.

INDEX

Africa, climate, 25
  labor in, 26, 28
  orebody in a mine, 31
Alaska, report of gold mines in, 46
American Smelting and Refining Co., 84
Anaconda Copper Mining Co., 85
Analysis of gold mine companies, 72, 77, 81
Assay plan, 32, 33
Australasia, gold production, 64
Australia, labor in, 26

Brakpan Mines, Ltd., 77, 91
British Columbia copper mine, 16

Canada, exploration in, 19
  gold production, 64
Capital expenditure *vs.* operating charges, 47
  required, 4, 39
Central Mining and Investment Corporation, 65
Churn drilling in copper deposits, 34
Climate, 6, 25
Companies, development, 17
  exploration, 19
Company control of properties, 14, 66
Compound discount table, 58
Consolidated Gold Fields of South Africa, 66
Consolidated Mines Selection Co., 66
Control, individual *vs.* company, 14
Copper mines, 8, 15, 16, 31
    analysis of, 84
    churn drilling, 34
    cost of mining, 39
    ore reserves in Utah, 87
    porphyry, value of, 53
    present value calculations, 89
Copper mines, production and price tables, 62
    report of profits, 45
  ore, flotation process, 15, 16
    leaching, 15
Cost of mining ore, 37

Depreciation, 47
Development companies, 17
  metallurgical, 15
  of mines, reduced, 50
Discount tables, 54, 58
Dividend tables, 54
  value of ore reserves, 74
Dividends, 53
  methods of increasing, 49
  vs. profits, 43
Dominions Royal Commission, 67
Drilling, churn, 34
  preliminary, 3

Earnings of mines, 43
Engineer's report on property, 2
Equipment, maintenance of, 52
  obsolete, 40
Estimates of cost, 38
  of value of property, 41
Exploration department of a company, 18

Faulting in mines, 31
Flotation, 15, 16
Future operations of mine, 59

General Mining and Finance Corporation, 66
Geographical situation, 23
Geological features of properties, 30
Goerz & Co., 66

Gold, market value, 61
  mines, 5, 9, 10, 31
    Alaska fields, 46
    analysis of Rand Companies' holdings, 72, 77, 81
    cost of shafts, 66
    estimate of value of, 60
    future production, 67
    present value, calculations of, 75, 80, 84
    reduced development, 51
    report of profits, 44
    selective mining in, 49
  production in the Rand, 65
    of world, 64

Homestake mine, 54
Honnold, W. L., 77
Hoover, H. C., 26, 54
Hoskold, tables of, 54

India, labor in, 26
Individual control of properties, 14
Industrial *vs.* mining investments, 70
Inspiration Consolidated Copper Co., 37, 88
Interest on capital. 53, 54
  tables, 54
Investments, mining *vs.* industrial, 70
Inwood, tables of, 54

Labor in mines, 6, 7, 26
Leaching of copper ore, 15
Lead, tables of production and price, 62
Lonely Reef Gold Mining Co., Ltd., 81, 91

Market value of mine product, 61
Metallurgical developments, 15
  treatment of ore, 35
Metals, future prices, 63
Mexico, gold production, 64
  gold-silver mine in, 50
  mines in, 13, 14
  mining methods, 52
  properties in, 23, 24, 31
Mills, premature erection of, 35
Mine products, valuing, 61
Mines, determination of value, 53
  future operations, 59
  non-producing, 2
  producing, 8
  speculative, value of, 54, 59
Mining, cost of, 37
  methods, unsuitable, 51
  properties, classification of, 1
    control of, 14
  report, analysis of, 23
  selective, 49
  vs. industrial investments, 70
Modder B. Gold Mines, Ltd., 74
Modder Deep Levels, Ltd., 74

Neuman, S., and Sons, 66
Nevada Consolidated Copper Co., 86, 90, 91
New Mexico, 29
New Modderfontein Gold Mining Co., Ltd., 72, 91

Operating charges *vs.* capital expenditure, 47
  profit *vs.* dividends, 43
Ore, cost of mining, 37
  metallurgical treatment, 35
  reserves, classification of estimates, 34
    copper, 87
    gold, in Rand, 72, 78, 83
    tonnage of, 32
Orebodies, occurrence of, 30

Peru, climate in, 26
Plant, premature erection of, 35
Porphyry copper mines, value of, 53
Present value, calculations of, 75, 80, 84, 89
  of a share, tables, 55
Prices of metals, tables, 62
Producing properties, 8
Production tables of metals, 62
Products, valuing, 61
Profits *vs.* dividends, 43
Properties, analysis of report, 23
  capital *vs.* operating charges, 47
  classification of mining, 1

Properties, estimates of value, 41
  climate, 6, 25
  control by company *vs.* individual, 14
  copper producing, 8, 15, 16
  depreciation, 47
  engineer's report on, 2
  geographical situation, 23
  geological features, 30
  gold-bearing, 5, 9, 10
  inoperative, 13
  labor problems, 26
  mixed-metal, 10
  non-producing, 2
  orebodies, occurrence of, 30
  producing, 8
  profits *vs.* dividends, 43
  reduced development to increase dividends, 50
  selective mining, 49
  timber supply, 30
  tonnage of ore reserves, 32
  topography, 29
  transportation facilities, 24
  unprofitable, 13
  water supply, 29
Prospectus, analysis of, 23
Public offering of shares, 2

Railway securities, 70
Rand, analyses of company holdings, 72, 77, 81
  climate in, 25
  future gold production, 67
  gold production, 64
  labor in, 28
  mining property in, 9
  ore reserves, 72, 78, 83
  report of gold fields, 44
  value of mines, 54
  working profits, 69
Report of a mine, analysis of, 23
Rhodesia, deposits in, 13, 29, 44, 81
Russia, exploration in, 20
  gold production, 64

Sampling ore, 32, 33
Securities, basis of selection, 1
Selective mining, 49
Share, determination of value, 53
  elements of value, 76
  present value, 75, 80, 84, 89
Shares, public offering of, 2
Siberia, gold production, 64
Silver, tables of production and price, 62
South America, climate, 25
  deposits in, 13, 15
  labor in, 28
Speculative investment, 17
  mines, value of, 54, 59
Steam-shovel mining, 30
Stoping width of orebody, 33

Tables of interest, dividend and discount, 54
Tanganyika deposits, 13
Taxes, 24
Timbered properties, 30
Time as factor of cost, 38
Tin, tables of production and price, 62
Tonnage of ore reserves, 32
Topography of properties, 29
Transportation facilities, 24
Transvaal Chamber of Mines, report of, 44
  gold production, 64
Treatment of ore, metallurgical, 35

United States, gold production, 64
United Verdes, 39
Utah Copper Co., 84

Value of mine products, 61
  of mining share, 53
  of property, estimates of, 41
Van Ryn Deep, Ltd., 74

Water supply, 29
Wernher, Sir Julius, 66
Witwatersrand, 64
Working profits in Rand, 69
World's gold production, 64

Zinc, tables of production and price, 62

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